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General Issue

Editor
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Editorial

Articles

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Editorial Issue 3 (2023)

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In this special issue we collect five papers covering different topics, all very relevant and at the core of the scientific debate within the Technology-Enhanced Learning research community.

The first two papers tackle the issue of gamification and Game-Based Learning. In particular, in the first paper, Min Lun Wu investigates teachers' attitudes, self-efficacy, teaching philosophy and perceived barriers towards the implementation of Game-Based Learning in class. This is done through a convergent mixed method study, during which pre-service, internship and in-service teachers are surveyed. Interestingly, the author concludes there seems to be a certain misalignment between teachers' endorsed teaching philosophy and their preferred game genre for use in class.

In the second paper, instead, Pellizzari proposes a systematic literature review about gamification in Higher Education, through which a picture is provided of the implemented experiences, with an attempt to detect their theoretical frameworks, design principles, proposed elements of gamification and impact on learning outcomes. The conclusions of the review emphasise the need for a functional, working model for gamification implementation which seems to be still missing. In this sense, we can say both the papers accepted for publication in this issue about gamification and Game-Based Learning somehow complain about immaturity of these fields and call for further research.

The following two papers have got a more subject-oriented focus, the former one being about teaching and learning English as foreign language, the latter about Science education.

In particular, Li et al. propose peer assessment as a technique to develop students' English translation skills and examine its impact on learning and motivation of students at different levels of achievement.

Bondì et al., instead, propose an inclusive approach to science communication to meet the needs of blind people, to contrast today digital tools, which are often rich in visual and abstract references and are difficult to be assimilated by those who have perceptual or sensory deficits.

In the last paper, Majorana et al. share a number of successful experiences carried out within a European project to develop students' critical digital literacy and active citizenship attitudes.

On average, IJET publishes every year a general issue collecting papers concerning various hot topics in Educational technology.

We are grateful to our authorship for sending their contributions all year round so that we can keep up with this policy, which gives us a "taste" of the current work in the field.

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Teachers' perceptions of implementing Digital Game-Based Learning in the classroom: A convergent mixed method study

La percezione degli insegnanti sull'implementazione in aula dell'Apprendimento Basato su Giochi Digitali: uno studio con metodo misto convergente

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ABSTRACT Research on Digital Game-Based learning (DGBL) indicated it is effective in inducing student motivation and learning outcomes. Teachers as gatekeepers of technology should maneuver DGBL as pedagogical approach to engage students. In this convergent mixed method study, the researcher surveyed 116 pre-service, internship, and in-service teachers about their attitudes, self-efficacy, teaching philosophy, and perceived barriers toward the implementation of DGBL. Qualitative and quantitative data were collected and corroborated. Results showed majority of teachers gravitated toward Edutainment Games and Educational Applications based on pre-existing familiarity, comfortableness, and ease of use. Findings revealed misalignment between teachers' endorsed teaching philosophy and their preferred game genre for use in instruction. The implication is that teachers during internship and post-induction should become educated in digital games and corresponding learning theory inherent in its design, so they can leverage teaching philosophy, knowledge and strategies to instruct in tandem with a pedagogically sound and thoughtfully chosen game.

KEYWORDS Digital Game-Based Learning (DGBL); Perceptions; Teacher Preparation; Teaching Philosophy; Mixed Methods.

SOMMARIO La ricerca sull'apprendimento basato sui giochi digitali (DGBL) ha dimostrato la sua efficacia nell'indurre motivazione e risultati di apprendimento negli studenti. Gli insegnanti, in quanto custodi della tecnologia, dovrebbero utilizzare il DGBL come approccio pedagogico per coinvolgere gli studenti. In questo studio effettuato con metodo misto convergente, sono stati intervistati 116 insegnanti in pre-servizio, in tirocinio e in servizio, in merito ai loro atteggiamenti, all'autoefficacia, alla loro filosofia di insegnamento e alle barriere percepite nell'implementare il DGBL. Sono stati così raccolti e validati dati qualitativi e quantitativi. I risultati mostrano che la maggior parte degli insegnanti è orientata verso giochi di edutainment e applicazioni educative basate su una loro familiarità preesistente, sulla comodità e sulla facilità d'uso. I risultati rivelano un disallineamento tra la filosofia di insegnamento adottata e il genere di gioco scelto per l'insegnamento. Ciò che se ne evince è che gli insegnanti durante e dopo il tirocinio dovrebbero ricevere una formazione sull'uso dei giochi digitali e sulle teorie dell'apprendimento sottostanti la loro progettazione, in modo da poter sfruttare la filosofia di insegnamento, le conoscenze e le strategie per insegnare in tandem con un gioco pedagogicamente valido e scelto con cura.

PAROLE CHIAVE Apprendimento Basato su Giochi Digitali (DGBL); Percezioni; Preparazione degli Insegnanti; Filosofia di Insegnamento; Metodi Misti.

1. Introduction

The 2018 Pew Research Center's study on 743 teens found that 84% of teens had access to digital game console and 90% played video games on a computer, tablet, console, or smartphone at home (Andersen & Jiang, 2018, p.9). The Entertainment Software Association (ESA) estimated that 214.4 million Americans played video games, with about 70% of children under the age of 18 playing games regularly (ESA, 2020). The ever-expanding game industry, increasing penetration rate of mobile technologies such as tablets and smartphones, and up and coming generations of digital game natives pose important questions and implications for teachers, practitioners, and teacher educators. Game research to date provided empirical evidence on games' effectiveness in inducing learner motivation, engagement, and learning outcome in both formal and informal settings (Barab, Gresalfi, & 2009; Connolly, Stansfield, & Hainey, 2011; Easterling, 2021; Gee, 2007; Van Eck, 2015). Two rationales support the use of DGBL. First, the thinking patterns of learners today have changed considering that they are native speakers and users of the languages of digital multi-media. Second, young people are experiencing innovative forms of computer and video game play and the continuing experience and exposure to these new forms of entertainment has an impact on their perceptions, cognitive abilities, and preference for learning (Prensky, 2007; Susi, Johannesson, & Backlund, 2007). Ultimately, DGBL is about leveraging the mechanisms and effects of digital games to motivate and engage learners for learning.

Despite the evidence and recommendations provided by the research community, does our teaching force acknowledge the utility of digital games in the classroom? Are teachers ready to teach and incorporate digital games into instruction? If we were to anticipate affirmative answers to the first and second question, are teacher educators taking note of the educational potential of digital games and deliberately act on preparing our future teachers to teach using digital games?

Meredith (2016) conducted a literature review on Digital Game-Based learning (DGBL) in K-12 teacher professional development and identified a gap in the literature, stating game-based learning in K-12 teachers' professional development as sparse. Teacher preparation and professional development should provide teachers with the tools to evaluate digital games' compatibility and suitability for use in classrooms (An, 2018). Research investigating pre-service and in-service teacher attitudes towards using digital games in the classroom showed that despite teachers' interest, teacher preparation has not done much to prepare teachers in using digital games in formal learning contexts (Hayes & Ohrnberger, 2013; Hsu & Chiou, 2011; Millstone, 2012; Takeuchi & Vaala, 2014). A dearth exists in the literature regarding a lack of educator training during teacher preparation and in-service professional development related to the use of DGBL (An, 2018; Denham, 2019; Groff, 2018; Stieler-Hunt & Jones, 2019). Takeuchi and Vaala's (2014) study on 694 American teachers in grades K-8 found 74% of respondents used digital games in their classrooms but only 8% learned about educational digital game usage during teacher preparation, and 17% learned about DGBL in in-service professional development. Findings pinpointed to the lack of incentivized preparation on using digital games during teacher preparation and in-service professional development.

Moreover, many studies have focused on teachers' attitudes towards DGBL. Kaimara, Fokides, Oikonomou, and Deliyannis (2021) examined 170 pre-service teachers' perceptions of the barriers to DGBL implementation and found via online survey that the major perceived obstacle is the inefficient allocation of available financial resources. Vogt (2018) conducted a qualitative study with eight purposively selected middle school teachers who use DGBL. Findings indicated these teachers use DGBL

to engage students in content, support skill building, promote teamwork and feedback. Factors that positively influenced adoption included teachers' own gaming experience and positive perception of using games to support lesson planning and classroom management. Negative perceptions were technical difficulties, lack of self-efficacy, time constraints, and the need for back-up plans. Gao, Li and Sun (2020) conducted a systematic review of mobile DGBL in STEM education and concluded teachers are concerned that the use of a mobile phone could disturb student learning or cause problems in classroom management.

From a practice-based perspective, Huizenga, Ten Dam, Voogt, and Admiraal (2017) interviewed 43 game-using secondary education teachers and found 41 teachers mentioned game-based learning to be effective in inducing student engagement, 38 teachers mentioned cognitive learning outcomes in formal teaching, whereas 17 teachers mentioned motivational effects via learning with games. Investigating best practices using games in teaching adds valuable insights and evidence to the usefulness and feasibility of game-based learning. Uluay and Dogan (2020) studied 18 pre-service teachers' usage of Kodu Game Lab in teaching science concepts and found the Kodu-using treatment group have more positive opinions toward DGBL compared with the control group.

1.1. Purpose of study and research questions

This study built upon findings from prior research in teachers' attitudes toward using digital games and extended the scope by examining potential relationships among factors such as teachers' attitudes, self-efficacy, teaching philosophy, and perceived barriers, which might facilitate or impede with teachers' adoption of DGBL in K-12 schools.

The term "digital games" used in this study refers to video games played digitally on a technological device such as home gaming console, handheld gaming device, tablet computer, cell phone or smart phone, and home computer.

Four research questions were formulated to guide this study.

1) What are teachers' attitudes toward implementing DGBL in the classroom?
2) What are teachers' perceived levels of self-efficacy on integrating DGBL?
3) What is the relationship between teachers' chosen game genre for DGBL and teaching philosophy?
4) What are teachers' perceived barriers toward using DGBL in the classroom?

2. Methods

Mixed methods is a research methodology in which "*a researcher or team of researchers combines elements of qualitative and quantitative research approaches for the broad purposes of breadth and depth of understanding and corroboration*" (Johnson, Onwuegbuzie, & Turner, 2007; p.123). To obtain a complete understanding of teachers' attitudes and perceptions of using DGBL, the study used a convergent mixed methods research design with the priority on the quantitative strand (see Figure 1). To corroborate the quantitative results, we collected qualitative data with the purpose of cross-validating multiple sources of findings within a single study (Collins, Onwuegbuzie, & Sutton, 2006; Creswell & Clark, 2017; Greene, Caracelli, & Graham, 1989).

3. Data collection and analysis

3.1. Sample and sampling

Participants of this study were 116 undergraduate and graduate students enrolled in educational technology courses in a large Midwestern university in the United States of America, including pre-service teachers (44%), student teachers in their internship year (20%), and in-service teachers (36%) in K-12 school settings in the US.

Survey was sent to a convenient sample of approximately 1,000 teachers with a response rate of 11% (116 fully completed responses). Among the 116 survey respondents, 85% (N=99) were female and 15% (N=17) were male. A combined 81.9% of respondents were between the age range of 18 to 26, with 69.8% of them preferred or were already teaching in K-6 settings.

3.2. Instrument

An online survey containing 33 five-point Likert scale items with qualitative probes and open-ended questions was administered via *Survey Monkey*, an online survey hosting site. The survey included four dimensions and items were adapted from existing scales:

1) 11 items about pre-teachers' attitudes toward using digital games in a classroom (Gibson, Halverson, & Riedel, 2007; Hsu & Chiou, 2011; Lambert, Gong, & Cuper, 2008; Millstone, 2012);
2) 9 items about perceived self-efficacy on the implementation of DGBL (Chatham, 2007; Egenfeldt-Nielsen, 2005);
3) 2 items about challenges and barriers to the adoption of DGBL in classroom settings (Baek, 2008; Becker, 2007; Kerbitchi, Kappers, Hirumi, & Henry, 2009; Rice, 2007), and
4) 4 items about teaching philosophy (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012). Five demographic items and two follow-up items were also included.

The Cronbach's alpha reliability of the four dimensions was averaged at 0.82.

3.3. Data analysis.

Quantitative data were analyzed in the Statistical Package for Social Sciences (SPSS 22) using descriptive statistics, Pearson bivariate correlations and exploratory factor analysis. Descriptive statistics was run for teachers' attitudes and self-efficacy in four game genres. Correlation analysis was performed to evaluate how teachers' teaching philosophy associated with their chosen genre of educational digital games to be used for DGBL in the classroom. Exploratory factor analysis was performed to examine the latent structures underlying the perceived barriers toward using DGBL. Qualitative data were coded using content analysis approaches guided by Krippendoff (2004). Pre-planned codes included for instance, "*fitting into content area and learning objectives*" (26 mentions), "*teacher demonstration and guidance*" (8 mentions), "*supplemental to whole group instruction or as a reward*" (11 mentions), and "*outcome assessment and meeting common core state standards*" (27 mentions). After data analysis, quantitative and qualitative results were juxtaposed and integrated for interpretation.

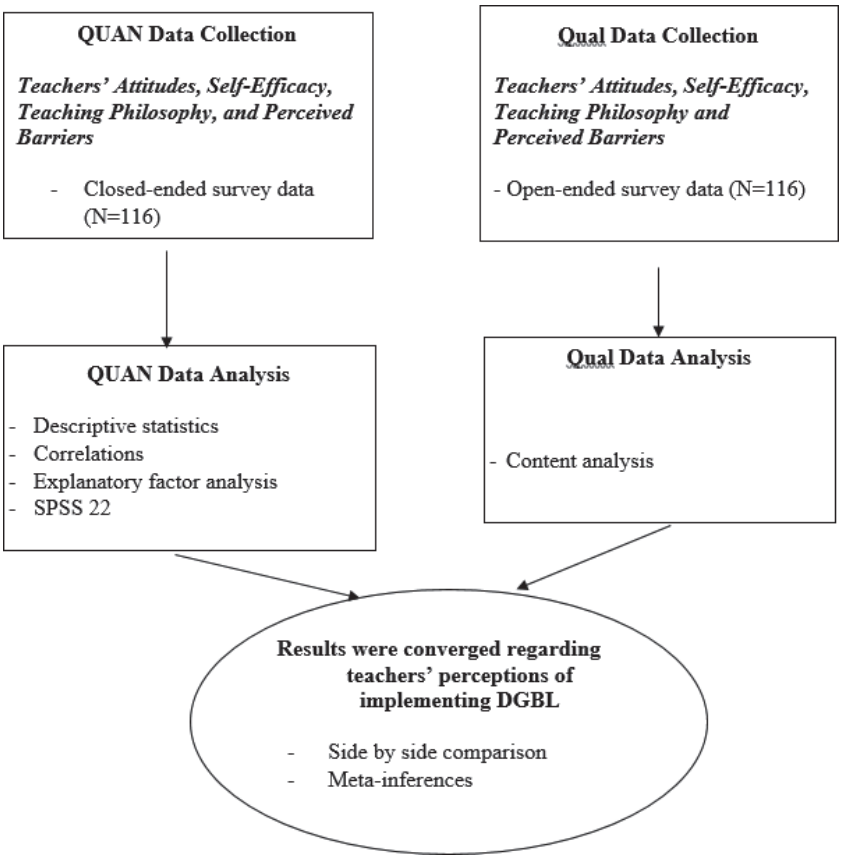

Figure 1. Methods of the study.

4. Findings

4.1. Attitudes toward using digital games in the classroom

Survey respondents held an overall positive attitude toward using digital games as tools for instruction (M=4.11, SD=0.87). A combined 77.6% of respondents (90 out of 116) expressed comfortableness in using digital games to supplement classroom instruction. Coincidentally a combined 77.6% of respondents (90 out of 116) chose "likely" or "very likely" in terms of likelihood of incorporating digital game-based learning. Consistency was found between respondents' favourable attitudes with their perceived likelihood of utilizing DGBL in the classroom.

Qualitative findings supported the above positive results, as participants indicated digital games "*learn and engage with life*", facilitative for practicing "*decision-making*", "*critical thinking*", and fantasizing "*alternate universes*". In specific, educational digital games were perceived as having a "*tie-in with subject area matter*". Many responses noted the extra practices afforded by the use of educational digital games in traditional subject areas of literacy, mathematics, and science, and they also provide a venue through which non-conventional skills such as creativity, problem-solving and motor skills can be honed in. Moreover, these games met the "*need for teaching young learners in ways that appealed to them*". Multiple responses mentioned that nowadays educational digital games are an integral part of kids' lives and these games are good at "*tricking students into learning*" and helping "*kids engaging in learning without realizing that they are*".

4.2. Self-efficacy on implementing DGBL

The researcher identified four genres of educational digital games based on review of literature on the historical development of educational games and contemporary learning theories (Wu, 2018; Flynn, Bacon, & Dastbaz, 2010; Games & Squire, 2011). Descriptions and screenshots of game play of the four game genres were provided to respondents to explicate what these genres entailed.

The four game genres include Edutainment and Educational Applications which highlight learning more than entertainment through rote learning and repeated practice; Serious games emphasize learning the hidden curriculum through gameplay and they promote learning in healthcare, corporate training, advertisement, civics, and politics; Educational game design tools are entry level game design platforms where players learn programming concepts and block-code; Simulation games and massive multiplayer online role-playing games (MMORPG) require players to cooperate and use strategic thinking, resource allocation, and role-play to make in-game progress.

The results indicated that regardless of participants' groups, they all ranked atop from the most favoured Edutainment Games and Educational Applications, to Serious Games, then Educational Game Design Tools, and lastly Simulation Games and MMORPGs (massive multiplayer online role playing games) (see Table 1).

Table 1. Mean, standard deviation, and ranking for the four game genres.

Genre by Teaching Status	*M* Pre / Int / Ins	*SD* Pre / Int / Ins	Ranking
Edutainment & Educational Apps	4.0 / 3.8 / 4.1	.95 / .78 / .79	Unanimous 1st
Serious Games	3.8 / 3.6 / 3.9	.79 / .83 / .83	Unanimous 2nd
Educational Game Design Tools	3.4 / 3.1 / 3.3	1.0 / .81 / 1.19	Unanimous 3rd
Simulation Games & MMORPGs	3.1 / 2.6 / 2.9	.99 / 1.0 / 1.33	Unanimous 4th

Note. Pre = Pre-service, Int = Intern, Ins = In-service. Mean score ranging from 1 to 5.

A combined 81% (94 out of 116) believed they were capable of using digital games to deliver educational contents in teaching and this showed their general optimism and belief in their self-efficacy to use DGBL. An ensuing item asked about their actual experience of using DGBL. Intriguingly 66.4% (77 out of 116) chose "no (experience in using games in teaching)" and this was counterintuitive to their optimism. In other words, even though 81% of respondents expressed self-efficacy in using DGBL but only 33.6% (39 out of 116) of respondents had actual experience using DGBL for educational purposes at the point of taking the survey.

Among the 33 Liker-scale survey items, 14 items included a text box for participants to expound opinions. In terms of the number of respondents choosing each of the four game genres to practice DGBL, the result was found to be the same as the order of preference ranking gathered from the four items completed earlier in the survey. The game genre Edutainment and Educational Applications received 69 mentions over the other three genres combined (38 mentions). In terms of ranking order, the same was found with Serious Games coming in at second with nineteen mentions, Educational Game Design at third with twelve mentions, and Simulation and MMORPGs with seven mentions. In sum, when it came to respondents' ranked preference of game genre for implementing DGBL, the results garnered from four items on game genre and an open-ended item were congruent.

4.3. Teaching philosophy

Four survey items asked about the four strands of contemporary teaching philosophies/learning theories – behaviourism, cognitive constructivism, social constructivism, and constructionism. Each teaching philosophy was accompanied by three statements to examine respondents' alignment or belief in teaching practices. In the attempt to test if the total of 12 sub-items were valid measures of respondents' teaching beliefs, bivariate correlation analysis was conducted. The result showed that the three sub-items in each of the four philosophies were significantly correlated with moderate to high coefficients ranging from .76 to .96 ($p < .01$, two-tailed). The Cronbach's alpha of each measure of the four philosophies was as high as .90 (see Table 2). Among the four philosophies, teachers resonated the least with the teaching beliefs of behaviourism, whereas the other three teaching philosophies received relatively equal and favourable acknowledgment.

Table 2. Mean Score on Teaching Philosophy.

Teaching Philosophy	M	SD	N of Items	Cronbach's Alpha
Behaviourism	2.73	1.17	3	.98
Cognitive Constructivism	4.14	.62	3	.93
Social Constructivism	4.06	.60	3	.94
Constructionism	4.17	.60	3	.94

Note. Items were rated on a 5-point Likert scale from 1 = strongly disagree to 5 = strongly agree, with a higher score indicating agreement with statements reflective of these teaching philosophies.

To investigate if there was alignment between the four types of teaching philosophies and the four identified game genres, a correlation analysis was performed. The following four findings emerged:

1) Behaviourism was negatively correlated with Educational Game Design Tools with statistical significance ($r = -.30$, $p < .01$).

This finding was relevant since the central learning tenet of behaviourism, stimulus and response (knowledge input and output in the form of observable behaviour), was at odds with the learning objectives such as creativity and artifact creation promoted by the exploratory and design-oriented activities involved in educational game design.

2) Cognitive Constructivism was positively correlated with Edutainment Games and Educational Applications ($r = .23$, $p < .05$), Serious Games ($r = .21$, $p < .05$), and Educational Game Design Tools ($r = .25$, $p < .01$) with statistical significance.

This finding was congruent with the previously stated notion that the four game genres are not mutually exclusive in terms of the learning objectives/opportunities they are designed to afford. For instance, even though Edutainment Games tend to be designed to promote learning as defined by behaviourism, these games can still be leveraged in ways to promote cognitive learning when a teacher employs pedagogical practices in line with cognitive constructivism by emphasizing the information taken in by an individual learner through schemata activation and cognitive processing.

3) Social Constructivism was positively correlated with Edutainment Games and Educational Applications ($r = .21$, $p < .05$), Serious Games ($r = .22$, $p < .05$), and Educational Game Design Tools ($r = .23$, $p < .05$) with statistical significance.

This finding seemed out of place considering that Edutainment Games and Serious Games were designed to promote individual learning processes and outcomes devoid the impact of social surroundings and participation.

4) Constructionism was positively correlated with Simulation Games & MMORPGs ($r = .19$, $p < .05$), and Educational Game Design Tools ($r = .32$, $p < .01$) with statistical significance.

4.4. Perceived barriers to the integration of DGBL

Exploratory factor analysis was performed to examine the latent structure underlying the 18 sub-items representing external barriers in implementing DGBL in one survey item. A parsimonious set of five components was extracted with 68% cumulative variance explained, including misalignment between DGBL and standardized curriculum, administrative and parental negative perceptions, lack of technology support and preparation in teacher preparation and professional support, short class periods, and low quality of educational digital games. For instance, a majority of respondents were first and foremost concerned about the budget of purchasing educational digital games, including "*cost of purchasing games*" (53.4%), "*inadequate computer or technology support to run digital games in the classroom*" (53.4%), and "not enough time to use digital game-based learning in short class periods" (50%). Some teachers also indicated that playing digital games might bring adverse effects to students, "*playing video games may have negative influences on my students*" (40.5%), "technology is distraction" (37.1%), "*low quality in graphics or audio effects in educational digital games*" (35.3%), and "*digital game-based learning cannot meet desired learning objectives*" (35.3%).

Qualitative analysis confirmed the above external barriers and they were misalignment between DGBL and standardized curriculum, administrative and parental negative perceptions, lack of technology support and preparation in teacher preparation and professional support, short class periods, and low quality of educational digital games.

4.5. Corroboration of quantitative results in qualitative responses

The analyses of respondents' qualitative responses corroborated the results of the quantitative analyses. These two data sources offered corroborated insights on respondents' perceptions of the value of DGBL converged on two emphases.

1) Teachers' lopsided preference for using Edutainment Games and Educational Applications and lack of familiarity with the other three genres of educational digital games: both the results of quantitative and qualitative data analysis pointed to the notion that teachers heavily favoured Edutainment and Educational Applications over the other three genres.

2) Misalignment between teachers' preference of Edutainment Games and Educational Applications and their endorsement in non-behaviouristic teaching philosophy: the rule of thumb is that Edutainment Games and Educational Applications are designed following learning principles of behaviourism because they focus on rote learning. While majority of teachers indicated preference for using this genre of games, it would have made sense that they endorse behaviourism as the teaching philosophy they resonated with. Instead, behaviourism received a low mean score of 2.73 as these teachers gravitated substantially more toward constructionism (M = 4.17), social constructivism (M = 4.06), and cognitive constructivism (M = 4.14).

See below Table 3 for a joint display table of the corroborated results.

Table 3. A joint display table of the corroborated results.

Corroborated Results	Qualitative Data	Quantitative Data
Teachers' lopsided preference for using Edutainment Games and Educational Applications and lack of familiarity with the other three genres of educational digital games.	Teachers all favoured edutainment and educational applications on a personal level and pedagogical level. In the content analysis, edutainment and educational applications were most frequently mentioned (69 times). Participants gave varied justification on their preference for using such genre of games, such as *"familiarity and comfortableness", "fitting into content area", "promoting positive learning", "engaging", "easy set-up", "appealing to and motivating for special education students", "easily used as supplemental materials/rewards for brain-break"*, etc. · *"I would work on cognitive ability and social skills within special education because I believe this (game) can help to bring both aspects in."* · *"The game provides motivation and student interest."* · *"I feel more comfortable in using the tools (games) to help me teach a standard than having the tool be the lesson itself."*	Edutainment and educational applications had the highest means among the four game genres (M=4.0 for pre-service teachers, M=3.8 for interns, M=4.1 for in-service teachers). Edutainment and educational applications was positively correlated with teachers' teaching philosophy (r=.23, p<.05) In the responses to the item, *"I believe I am capable of using digital games to deliver educational contents in my teaching"*, 62.9% of all participants chose "agree" with "strongly agree" coming in second at 18.1%.
Misalignment between teachers' preference of Edutainment Games and Educational Applications and their endorsement in non-behaviouristic teaching philosophy.	Majority of teachers indicated preference for using edutainment games and educational applications that were designed following learning principles of behaviourism with a focus on inducing learning in the form of stimulus and response. · *"Use the game as a partner/independent practice after a mini lesson."* · *"Learning objectives would be to maintain measurable checkpoints and continuous challenges rather than having them just practice what is comfortable."* · *"I would pick a game that scaffolds what they have already learned."* · *"The game should give immediate feedback of correct or incorrect responses/answers."*	Behaviourism (M=2.73, SD=1.17) resulted the lowest mean among all types of teaching philosophy. Behaviourism was negatively correlated with educational game design tools (r=-.30, p<.01).

5. Discussion and conclusion

The misalignment between the chosen game genre and teaching philosophy pointed to two observations. First, teachers may not have been cognizant of the behaviouristic learning principles infused in the design of Edutainment Games and Educational Applications. Their favourable attitudes toward adopting this genre of games arose mainly from familiarity, comfortableness, and the ease of set-up. Second, considering the discrepancy between mean scores, the teachers apparently felt more in line

with the learning principles of constructionism, cognitive constructivism and social constructivism, but not as prominently in behaviourism. The fact that the teachers favoured Edutainment Games and Educational Applications yet the teaching philosophy they endorsed was not compatible with the chosen genre of educational games may lead to a misalignment between teaching materials and pedagogical strategy, hence rendering DGBL less effective. From teachers' standpoint, finding suitable games to use for the skills needed to be taught is of critical importance. To achieve this, teachers need to find resources and become educated in the genres of educational digital games and the corresponding learning theories inherent in its design, so that they can better leverage their teaching philosophy, knowledge and skills to teach in tandem with a compatible genre of educational digital game. A combination of personal and pedagogical factors led to their preference. On a personal level, teachers may already have established prior experience, familiarity and comfortableness with Edutainment games and Educational Applications. On a pedagogical level, these short-form games and applications are ideal for the attention span of younger age students (majority of the survey respondents self-identified as K-6 teachers) and they are in general simple to set up. More importantly, Edutainment games and Educational Applications provide accompanying lesson plans for teachers. Thus these games serve as convenient, expedient and intuitive fit for delivering educational content in classrooms.

This study provides contribution to the literature in studying the use and inculcation of DGBL in teacher education programs (Franklin & Annetta, 2011) and the attitudinal survey served as tool and foundation on which to bridge theory to practice in teachers' pedagogical usage of educational digital games in a classroom setting. Continuing research in the use of DGBL is important because DGBL supports students' growing interests, constructs new areas of technological and knowledge base, and sustains student motivation to learn (Barab et al., 2009; Caperton, 2010; Papastergiou, 2009; Rankin, McNeal, Shute, & Gooc, 2008; Richter & Dawley, 2010). Despite a growing number of studies on using educational digital games to support student learning in K-12 subject content areas (Charsky & Mims, 2008; Connolly et al., 2011; Gros, 2007; Ritzhaupt, Higgins, & Allred, 2010; 2011; Squire, 2005), there is lack of evidence demonstrating DGBL is effective and compatible with formal learning contexts in most schools and districts.

Adding to the issue of incompatibility, the variety of game genres, different methods for integrating games into instruction, and poor quality of many educational games complicate the adoption of DGBL in classrooms (Gee, 2007; Tobias & Fletcher, 2011; Young et al., 2012). The diversity of educational games, the different ways of incorporating games into instruction, and the complexity of measuring game-based learning add to the challenge of using digital games for teachers (Molina-Carmona & Llorens-Largo, 2020; Ren, 2019), requiring them to have "*more than a superficial understanding of game elements to make informed decisions about their use*" (Hayes & Ohrnberger, 2013, p.155). On one hand, we need more empirical studies documenting the processes and pedagogies of incorporating digital games into K-12 curricula (Van Eck, 2015). On the other, the field of study in DGBL needs a guiding framework with which we can reference in tackling problems arising from the integration of DGBL in the classroom.

The manner in which teachers navigate to understanding different genres of educational digital games, the embedded learning principles and the design implications can potentially influence their choice, pedagogy, and implementation of DGBL in a classroom. Sandford, Uicsak, Facer and Rudd (2006) called for the differentiation between types of learning opportunities afforded to teachers b different genres of games and stated that the differentiation would aid the process of coming to a fuller understanding of the potential of using digital games in education (p.3). Among many others, a typology of educational digital games might serve to assist teachers in understanding the pedagogical impli-

cations of adopting the four genres of games and how their teaching philosophy may factor in depending on their chosen game genre (Wu, 2018).

Emerging technologies such as virtual reality, augmented reality, and mixed reality markets are expected to increase and so are hardware and software usage. Extended reality (XR) games deliver deeply immersive experiences for learners by placing them within rich simulated environments (Madden et al., 2020) and such technologies had found a stronghold in corporate setting and military training, and it is safe to assume that they are, if not sooner, set to impact education where true immersion and heightened engagement can be realized for the benefits of student learning and teaching.

Findings of this study provide teachers and teacher educators with insights on effectively implementing DGBL, one such consideration being thoughtfully align teacher's teaching philosophy with a chosen game genre for use in classroom instruction. Many studies found the lack of training during teacher preparation and professional development hinders teachers' willingness, comfort, and confidence in the use of DGBL (Easterling, 2021; Meredith, 2016; Stieler-Hunt & Jones, 2019). There should be shared responsibility in teacher preparation programs where teacher educators impart knowledge about DGBL to pre-service teachers and in in-service professional development through which teachers can develop confidence and skills in using DGBL. When teachers received training associated with implementation of DGBL, their comfort and confidence increase, the game-based lesson would be carried out more effectively, and student learning would improve (An, 2018; Stieler-Hunt & Jones, 2019; Takeuchi & Vaala, 2014). Another solution lies in teachers themselves actively seeking to improve pedagogical practices by keeping up to date with resources and information about using emerging technologies for teaching and learning. It is imperative for teachers to equip themselves with a malleable mindset, rather than a fixed skill set, when it comes to navigating through the constantly changing landscape of educational technology.

5.1. Limitations

Several limitations should be considered in interpreting the findings of this study. First of all, the subjects under study were by no means fully representative of the teaching force considering that the respondents were limited to a pre-determined pool of teachers from a large Midwestern university in the US. Secondly, this study was exploratory in that the attitudinal survey was piloted to gauge 116 teachers' perceptions toward DGBL and the survey has not been extensively tested beyond the confines of the current study. Thirdly, the usage of one survey item to gauge teaching philosophy presented threats to validity and reliability. Fourthly, the collected data were self-reports that were subjective and may reflect response biases.

5.2. Implications for Future Research

One future direction for research is to investigate whether misalignment between teachers' choice of game genre and their teaching philosophy would induce adverse effects on using DGBL for instruction. While extant research does not address the relationship between teaching philosophy and game genre, the importance for teachers to understand the varying design and learning principles embedded in the four genres of educational digital games cannot be over-emphasized. Teachers need to be cognizant of their choices of technology tools and how their choices subsequently weigh in on their approach in the set-up, instructional practices, delivery of subject area contents, and outcome assessment.

Another research direction is to emulate large-scale studies (Millstone, 2012) by augmenting the sample size to a national level where the researcher-developed survey can be validated. In a similar vein, Easterling (2021) conducted a quantitative study surveying pre-service and in-service teachers (N=345) enrolled in a large Midwestern University in the US about their perceptions of benefits and barriers to the implementation of DGBL. Findings pointed to the lack of teacher training aligned with the integration of digital games into the classroom, despite the majority of responding teachers perceiving DGBL to be useful as supplemental activities that are motivating and could provide instantaneous feedback to learners. The study also concluded with recommendations for school administrators that there should be professional development offerings aligned to DGBL and on-site technology support personnel to provide support in teachers' planning for the use of DGBL in classrooms.

Well-received is that the responsibility of teachers is to design and deliver learning experiences that captivate and engage learners. One of these designed learning experiences may entail creativity and creativity on the part of teachers during instruction would in turn inspire creativity in students' endeavour to learn contents and produce evidence, prowess, and artifacts of learning. DGBL represents such a venue of pedagogical practice that requires persistence on creative teaching and purposeful play on the part of learners. After all, learning is and should be fun, motivating and fulfilling when a teacher has the capacity to leverage DGBL and engage learners via creative, meaningful, and purposeful play.

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Gamification in higher education. A systematic literature review

Gamification nell'istruzione superiore. Una revisione sistematica della letteratura

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ABSTRACT This article explores the transformative role of gamification in higher education through a systematic literature review. Rooted in the concept of gamefulness, gamification involves the intentional integration of game elements to enhance student engagement and learning experiences. The systematic literature review focuses on gamification in higher education, using the PRISMA model to conduct the analysis. The search protocol employs a rigorous search strategy using five online databases, excluding non-English language articles and duplicates. Adopting an aggregative review approach, the study delves into the theoretical framework of gamification, tracing its definitions, underlying principles and potential impacts on learning outcomes. The narrative textual synthesis of the 53 selected articles reveals a diverse landscape of gamification implementations in higher education, highlighting challenges in the uniformity of theoretical and empirical analyses. Then a thematic analysis is also proposed exploiting the results of a "meta-summary", to explore the relationships among themes. The conclusions emphasise the need for a functional, working model of gamification implementation to effectively address teaching improvement goals.

KEYWORDS Gamification; Higher Education; Systematic Literature Review; Engagement and Motivation; Active Learning.

SOMMARIO L'articolo esplora il ruolo trasformativo della gamification nell'istruzione superiore attraverso una revisione sistematica della letteratura. Radicata nel concetto di gamefulness, la gamification comporta l'integrazione intenzionale di elementi di gioco per migliorare il coinvolgimento degli studenti e le esperienze di apprendimento. La revisione sistematica della letteratura si concentra sulla gamification nell'istruzione superiore, utilizzando il modello PRISMA per condurre l'analisi. Il protocollo di ricerca impiega una strategia di ricerca rigorosa utilizzando cinque database online, escludendo gli articoli non in lingua inglese e i duplicati. Lo studio, che adotta un approccio di revisione aggregativa, approfondisce il quadro teorico della gamification, tracciandone le definizioni, i principi di base e i potenziali impatti sui risultati dell'apprendimento. La sintesi narrativa testuale dei 53 articoli selezionati rivela un panorama variegato di implementazioni della gamification nell'istruzione superiore, evidenziando le sfide nell'uniformità delle analisi teoriche ed empiriche. Successivamente, viene presentata un'analisi tematica che si avvale dei risultati di un "meta-sommario" al fine di esplorare le relazioni tra i diversi temi. Le conclusioni sottolineano la necessità di un modello funzionale e funzionante di implementazione della gamification per affrontare efficacemente gli obiettivi di miglioramento dell'insegnamento.

PAROLE CHIAVE Gamification; Istruzione Superiore; Coinvolgimento e Motivazione; Apprendimento Attivo.

1. Introduction

Gamification, a concept born from the convergence of game design elements and non-game contexts, has emerged as a transformative force in various domains, including the realm of higher educa-

tion. This study aims to provide a nuanced exploration of gamification in higher education, delving into its definitions, underlying principles, and potential impacts on learning outcomes.

The British game programmer Nick Pelling introduced the term 'gamification' in 2002, which gained widespread attention in 2010 following Jesse Schell's discourse at the DICE conference. Thereafter, Deterding et al. (2011) defined gamification as the use of game design elements within contexts unusual to gaming. In the context of higher education, this involves the intentional infusion of game elements into educational practices, creating an environment that fosters engagement, motivation, and interactive learning experiences (Goethe, 2019; Kaliban et al., 2023).

At its core, gamification engages with the practical experience and behavioural qualities of play, referred to as 'gamefulness'. Deterding's framework further delineates the aspects of "gameful interaction" (objects enabling play quality) and "gameful design" (the deliberate design of gamefulness).

When using gamification in higher education contexts, this should be done by integrating game design elements not as mere embellishments, but as strategic components aimed at enhancing student engagement and overall learning experiences (Riar et al., 2022).

Importantly, Kapp's definition (2012) positions gamification as a comprehensive strategy involving game-based mechanics, aesthetics, and playful thinking. Within the educational context, this multifaceted approach encompasses game-based objectives, mechanics such as levels, points, and badges, aesthetics, game thinking, participant involvement, motivation, learning promotion, and problem solving (Burke, 2016).

Thus, the integration of these elements goes beyond superficial enhancements, establishing an immersive and adaptive educational environment (Sercemeli & Baydas Onlu, 2023). Indeed, the characteristics outlined by Kapp underscore gamification's potential as a holistic educational strategy, rather than a standalone technological overlay. A well-designed gamified system provides an alternative rendering or approximation of reality, offering hypothetical, imaginary, or fictitious experiences that resonate with learners (Landers et al., 2015). Moreover, the gamified structure, when aligned with broader educational objectives, enhances the presentation and delivery of core educational content (Kam & Umar, 2022).

An essential contribution of gamification to higher education is the reduction of the fear of failure: in a gamified learning environment, students are encouraged to explore, take risks, and learn from consequences, mirroring the adaptive nature of games (Toda et al., 2019). In fact, Kapp's emphasis on the addictive elements of gamification, such as a sense of accomplishment, cooperation learning, immediate feedback, and the reduction of the burn of failure, highlights the motivational aspects of gamification crucial for sustained engagement.

Vesa's perspective (2021) adds depth to this framework by highlighting that gamified systems should be intrinsically driven by non-game objectives. Importantly, successful gamification in higher education must align with broader educational goals and objectives (Jagoda, 2020). In particular, the gamified structure should not overshadow, but rather enhance the core educational content, ensuring that it remains central to the learning experience (Richter et al., 2015).

In ensuring the implementation of effective gamification in higher education, a player-centred approach is of paramount importance (Nicholson, 2015). Understanding the goals and motivations of students should allow educators to tailor gamified solutions that resonate with the learner demographic (Hallifax et al., 2019; Perez-Aranda et al., 2023).

Thus, Boller and Kapp's (2017) suggest an empirical approach encouraging designers to explore, collect data, and recognise patterns in learner behaviour, ultimately ensuring that the gamified elements align seamlessly with educational objectives.

In this contribution, we propose a systematic literature review, which further explores the adoption of gamification in higher education contexts, in an attempt to further understand the state of the art in this sector.

2. Design and analysis of the systematic literature review

The notion of gamification in education has been explored in several Systematic Literature Reviews (SLRs) (Morandi & Camargo, 2015; Hamari et al., 2014; Caponetto et al., 2014; Rodrigues et al., 2020; Manzano-León et al., 2021). In these studies, the topic is addressed rather broadly and not specifically in the context of higher education, by critically assessing gamification's theoretical foundations, methodological approaches, models, platforms, apps, mechanics, and learning outcomes. Some other studies explore e-learning and online training interventions (Antonaci et al., 2019; Saleem et al., 2022), while others focus on sporting activities (Koivisto & Hamari, 2019), medical prevention (Johnson et al., 2016; Muangsrinoon & Boonbrahm, 2019), business management (Ferreira et al., 2017; Silva et al., 2019), and tourism (Pasca et al., 2021). In this study, we narrow the scope to the specific context of higher education, as it is further explained in the following section.

2.1. Research questions

As already mentioned, in our study, we decided to focus on gamification in higher education. Although in the recent literature, you can find other similar literature reviews (Subhash & Cudney, 2018; Castillo-Parra et al., 2022; Khaldi et al., 2023), we decided to devote ourselves to a detailed analysis focusing on the various phases involved in the didactic design of gamification (Mora et al., 2015), examining the stages from the initial conception of the objectives to the subsequent implementation phase. While there exist comparable literature reviews in recent scholarly works (Subhash & Cudney, 2018; Castillo-Parra et al., 2022; Khaldi et al., 2023), our distinct contribution lies in our deliberate choice to immerse ourselves in a comprehensive exploration of the intricacies within the didactic design of gamification. Instead of providing a broad overview, we have undertaken a specialized analysis that meticulously dissects the diverse phases integral to the didactic design process. Our focus spans from the inception of educational objectives, where the groundwork is laid, to the subsequent and equally pivotal phase of implementation. By narrowing our scope to these specific stages, we aim to offer a nuanced understanding of how gamification can be strategically conceptualized and seamlessly integrated into educational practices (Majuri, Koivisto & Hamari, 2018), providing unique insights that extend beyond the purview of existing literature reviews. Therefore, we addressed three research questions:

- RQ1. Has gamification been implemented in higher education since 2011? How is the term 'gamification' geographically distributed within the scientific literature?
- RQ2. What theoretical vision do the relevant studies foreground? What is the focus of the studies (in terms of research questions and hypotheses)? What are the modes and duration of implementation?
- RQ3. What are the factors influenced by gamification in the retrieved studies? What are the elements of gamification adopted? What are the learning outcomes addressed?

Based on the above questions, we adopted the PICO framework (Uman, 2011; Kitchenham, 2012), which helped to delineate the parameters of our study. Hence, the Population (P) includes higher education students and teachers. The chosen Intervention (I) for this SLR is gamification. The Control/

Comparison (C) involves the elements intrinsic to gamification implementation, theoretical models, and anticipated learning outcomes. Finally, the Outcomes (O) encompass the varying positive impacts of gamification on the population and the emerging best practices in gamification design, management, and evaluation. As required by the protocol, the SLR contains only primary studies.

2.2. Review type

The review type we choose for this research is an 'aggregative review', specifically a realist review (Popay et al., 2006), i.e. an interpretive technique that integrates qualitative and quantitative research evidence within specific contexts (Saini & Shlonsky, 2012). In line with aggregative reviews, this study allows a precise and in-depth analysis and synthesis, focusing on specific elements and detecting outlined gamification models.

The synthesis approach we chose is the Textual Narrative Synthesis (Littell et al., 2008), an aggregative approach that organises studies into more homogeneous groups. This synthesis method involves comparing study characteristics, context, quality and results, highlighting both similarities and differences (Henderson et al., 2010).

Another analysis method used was the "meta-summary", i.e. a method that aims to integrate results retrieved from thematic summaries or data investigations (Sandelowski et al., 2007). For this purpose, it is necessary to extract, group, abstract and format the results, but also calculate the frequency and intensity of the effects (Ghirotto, 2020). The meta-summary aims at investigating the retrieved qualitative studies, to understand what their focus is and what topics they address. The strategy for creating the meta-summary involved a thematic analysis of the retrieved articles, the assignment by the coders of themes and sub-themes to each article and the following creation of a conceptual map of the relationship between the themes. Finally, starting from these themes, the calculation of their frequency in the sample and their intensity was carried out.

2.3. Research protocol and PRISMA system

We decided to use five online citation databases through which to search the existing literature (see Table 1).

Table 1. Databases used in this SLR.

Databases	Web sites
Google Scholar	https://scholar.google.com
JSTOR	https://www.jstor.org/
ERIC	https://eric.ed.gov/
Web of Science (WoS)	https://www.webofscience.com/wos/woscc/basicsearch
Scopus	https://www.scopus.com/

Notably, in this study we deliberately decided to avoid exploring social databases, such as Academia and ResearchGate, in order to prioritise primary, peer-reviewed work and exclude grey literature, guided by the reflection table proposed by Garousi et al. (2018). Only articles written in the English

language between 2011 (the inception of the term 'gamification') to June 2023 were considered, and the search focused solely on open-access articles in the specified databases. Our article collection was managed with the Mendeley programme[1], a free reference manager supporting the storage, organisation, annotation, and sharing of references and research data. A list of keywords for the search string across all databases was defined based on the previously mentioned PICO framework.

The search string, using Boolean operators (Scells et al., 2020) was the following:

Gamif AND (online OR blended OR hybrid) AND (higher education OR university OR academic OR college) AND (teacher* OR student*)*

We decided to use asterisks (*) to include in our search all the lemmas derived from and possibly related to the subject of the investigation (e.g. gamif* to cover terms such as gamified, gamify, and gamification). The search was performed on titles, keywords and abstracts. Moreover, to manage the potentially vast pool of irrelevant studies resulting from a full-text search in the databases, non-English articles and duplicates were excluded from the considered body of literature.

The search string's accuracy was ensured by manually verifying its effectiveness through the identification of relevant publications. This validation process involved confirming that the search returned these publications in one of the selected bibliographic sources. Following the definition of the search string and source, eligibility criteria (for both inclusion and exclusion) were established to guide the selection of primary studies for this study's review. Additionally, inclusion criteria were predetermined to set the minimum conditions justifying a study's admission into the review. In contrast, exclusion criteria were determined later during the eligibility process.

The resulting final list of the inclusion and exclusion criteria is provided in Table 2.

Table 2. Criteria for inclusion and exclusion of this study's SLR.

Inclusion criteria	Exclusion criteria
Peer review	MOOC (Massive Open Online Courses)
Language: English	Exclusive use of Audience Engagement Tools (Kahoot!, Quizizz, Mentimeter, Socrative, WooClap, etc.)
Explicit gamification elements	Experimentation of less than 3 hours/1 lesson
Implementation in Higher Education (empirical papers)	Implementation in primary and/or secondary schools and in settings such as marketing, health, business, fashion, etc.
Between 2011 and 2023	Use of Virtual Reality (VR) and Augmented Reality (AR)
Use of experimentation monitoring/evaluation tools (both qualitative and quantitative)	Use of Game Based Learning and Escape Rooms

The exclusion criteria were chosen for specific reasons:

- MOOCs (Massive Open Online Courses): Due to significant differences in design, delivery, and beneficiaries compared to traditional higher education courses, MOOCs are excluded.
- Exclusive use of AET (Audience Engagement Tools): Sole reliance on AET does not constitute gamification, but only a potential short-term engagement, leading to exclusion.

[1] On the Internet: URL https://www.mendeley.com/search/

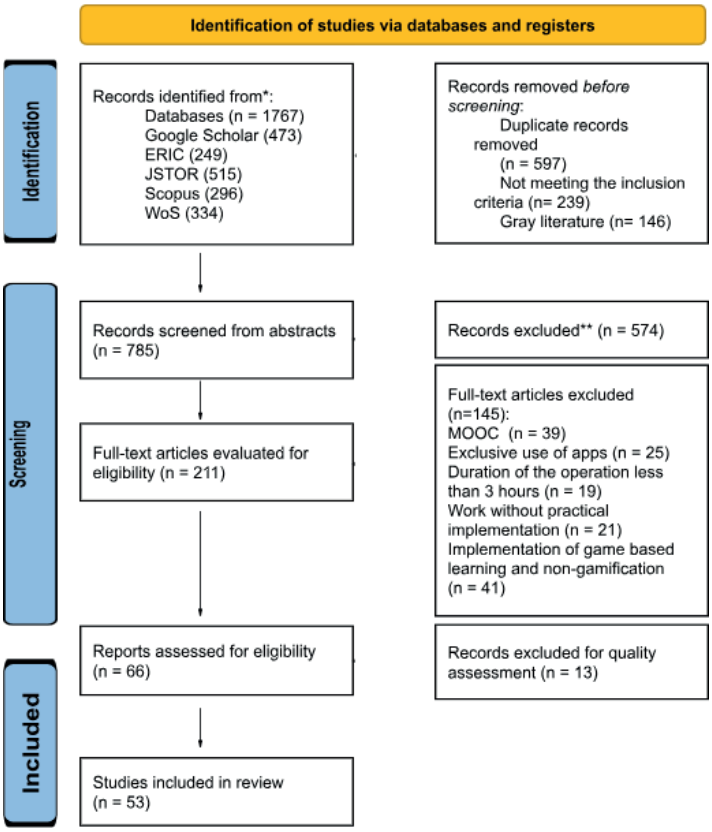

Figure 1. PRISMA diagram.

- Implementation outside higher education: This choice aligns with the SLR's scope i.e. focusing on higher education.
- Use of AR (Augmented Reality) and VR (Virtual Reality): Due to their complexity and resource-intensive nature, studies involving AR and VR are excluded based on practical and economic considerations.
- Game Based Learning and Escape Room: Their exclusion is based on the common conflation of gamification with these models, ensuring the selection of studies implementing gamification as defined by this review.

Moreover, the 2020 version of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Flow Chart was used to configure the search (see Figure 1). No automation systems were used, but the researchers did the selection manually.

The diagram illustrates the path of information through the various stages of a systematic review, plotting the number of records identified, included and excluded, together with the reasons for the exclusions. Indeed, the initial paper count is substantial, with a notable presence of duplicates across various databases. The above diagram also illustrates the considerable exclusion of works during the initial screening phase. The misuse of the term 'gamification' in the literature and frequent instances of applications outside higher education contributed to the significant reduction in the identified works.

2.4. Biases mitigation

Before commencing the research, we made efforts to minimise biases[2] in order to avoid their potential impact on research reliability (Higgins et al., 2011). Specifically, our SLR addressed five types of biases: publication bias, time interval bias, location bias, language bias, and selection bias (Gough, Thomas, & Oliver, 2019).

Publication bias, the most significant among others, was mitigated by employing a complex search string and Boolean operators. Time interval bias was minimised by including studies from 2011 to 2023, aligning with the first definition of gamification by Deterding (2011). Location bias was curtailed by utilising results from five diverse databases, including two that are specialized in education (ERIC and JSTOR).

Notably, while linguistic bias remains unresolved, we acknowledge this and note it as a limitation in this SLR. We also considered selection bias, taking into account the high number of papers identified in the initial phase (1767). Noting these considerations and the established protocol, we subsequently proceeded with our review and analysis.

3. Results

Below we present the obtained data that can be used to answer our research questions. Included within the final References list there are the 53 selected post-SLR articles (marked with an initial asterisk), excluding the 14 articles that did not pass the quality assessment stage (Carroll & Booth, 2015).

3.1. Geographical and time distribution of studies (RQ1)

Figure 2 shows the geographical distribution of the retrieved studies. The data reveal the majority of articles relevant to our study originate from the United States of America (USA), followed by Turkey, Spain, and Hong Kong.

Publications on higher education began in 2013, with the highest volume being witnessed in that year. From 2014 to 2016 and between 2021 and 2023, the average percentage of publications on higher education is 7% (N = 4). Surprisingly, the majority of selected studies were found to have been conducted between 2010 and 2018, in contrast with our expectation of finding more studies during or post the COVID-19 time.

3.2. Founding theories (RQ2)

The founding theories cited in the articles considered in this SLR are very diverse and complement each other. As we can see in Figure 3, the most cited founding theory turns out to be Deci and Ryan's self-determination theory (SDT) (2012), with a presence of 38.46% (N = 20). The other theories are instead presented and cited in a very different and scattered manner: among these, Bartle's (1996) classification of player types is notable (5.77% presence, N = 3), tied with flipped classroom (Ozdamli & Asiksoy, 2016), goal setting (Latham & Arshoff, 2013), and social comparison theory (Festinger, 1957). Again with a presence of 5.77% (N=3), game-based learning emerges as a relevant theory: hav-

[2] Biases in this area are defined as variations and/or deviations in the literature review that alter and distort the analysis and synthesis of studies, thus leading to the final overview not being reliable and replicable.

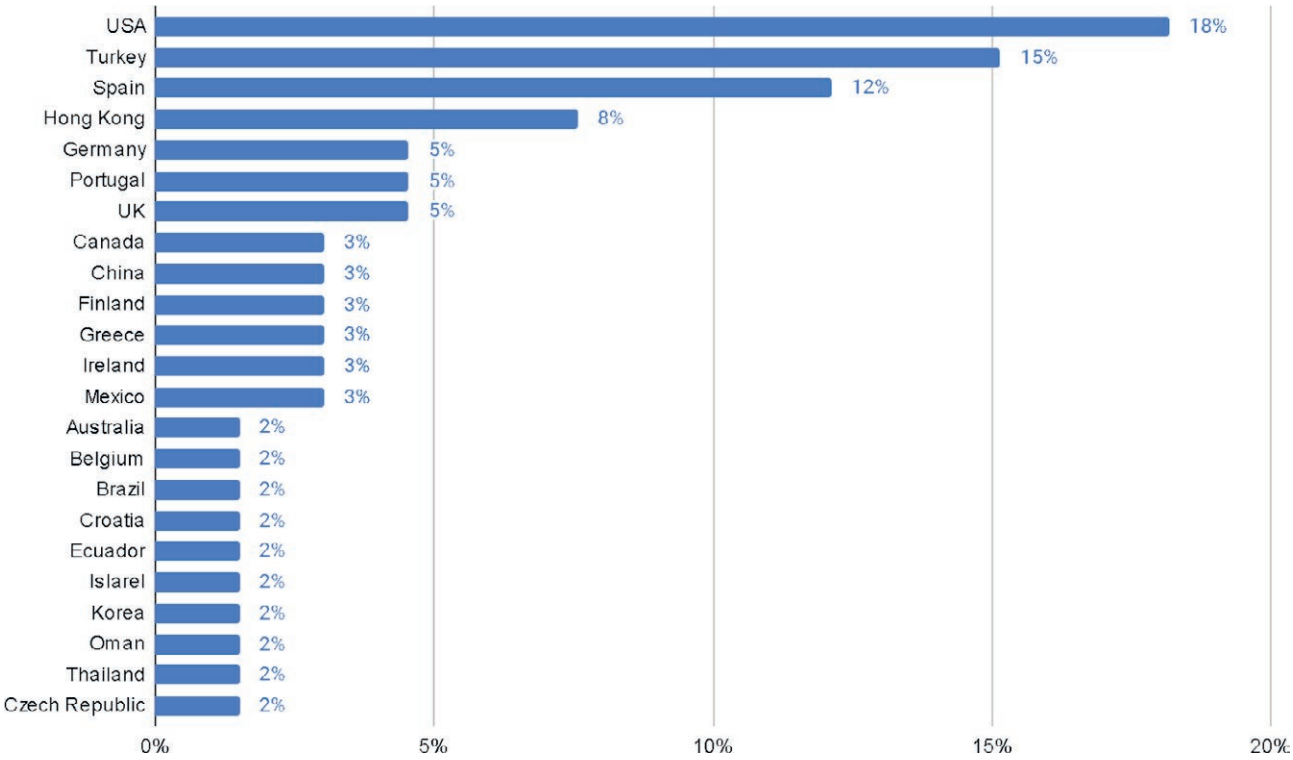

Figure 2. Origin of studies.

ing eliminated at an early stage the articles that confuse gamification with game-based learning, in the selected articles we found that gamification is mentioned from the point of view of the use of game elements revised and implemented in a gamified didactic model; this is why they were included in our SLR. Finally, it is necessary to dwell on the MDA (Mechanics, Dynamics, and Aesthetics) framework (Hunicke et al., 2004): it is directly included as the basic framework of gamification itself, while we found some authors choose to favour this framework as one of the theories on which gamification is based. With smaller percentages of presence (3.85%, N = 2) emerge the flow theory (Csikszentmihalyi et al., 2018), the GAFCC model (Goals, Affordances, Feedback, and Constraints Model) (Huang & Hew, 2018), Kolb's learning styles (1984), Nicholson's meaningful gamification (2015), student engagement, and the value of active learning.

A reflection can be made on the latter theories mentioned above: not all authors claim that the flow theory is attainable and/or verifiable with gamification – especially when it is protracted over a long period of time (Oliveira et al., 2022) – just as not all studies claim to be able to contribute to students' learning styles, since gamification is an educational approach and - as such – it attempts to adapt to all possible learning styles (Buckley & Doyle, 2017). Additional insights gleaned from our study prompt contemplation on two noteworthy aspects: meaningful gamification and the GAFCC model. While not constituting foundational theories in the conventional sense, these frameworks offer more detailed specifications and in-depth examinations of gamification. Specifically, meaningful gamification and the GAFCC model approach gamification from a didactic and educational learning perspective, surpassing mere theoretical foundations. Rather than being abstract concepts, these frameworks serve as comprehensive theories that furnish researchers with valuable guidelines and reflections. They delve

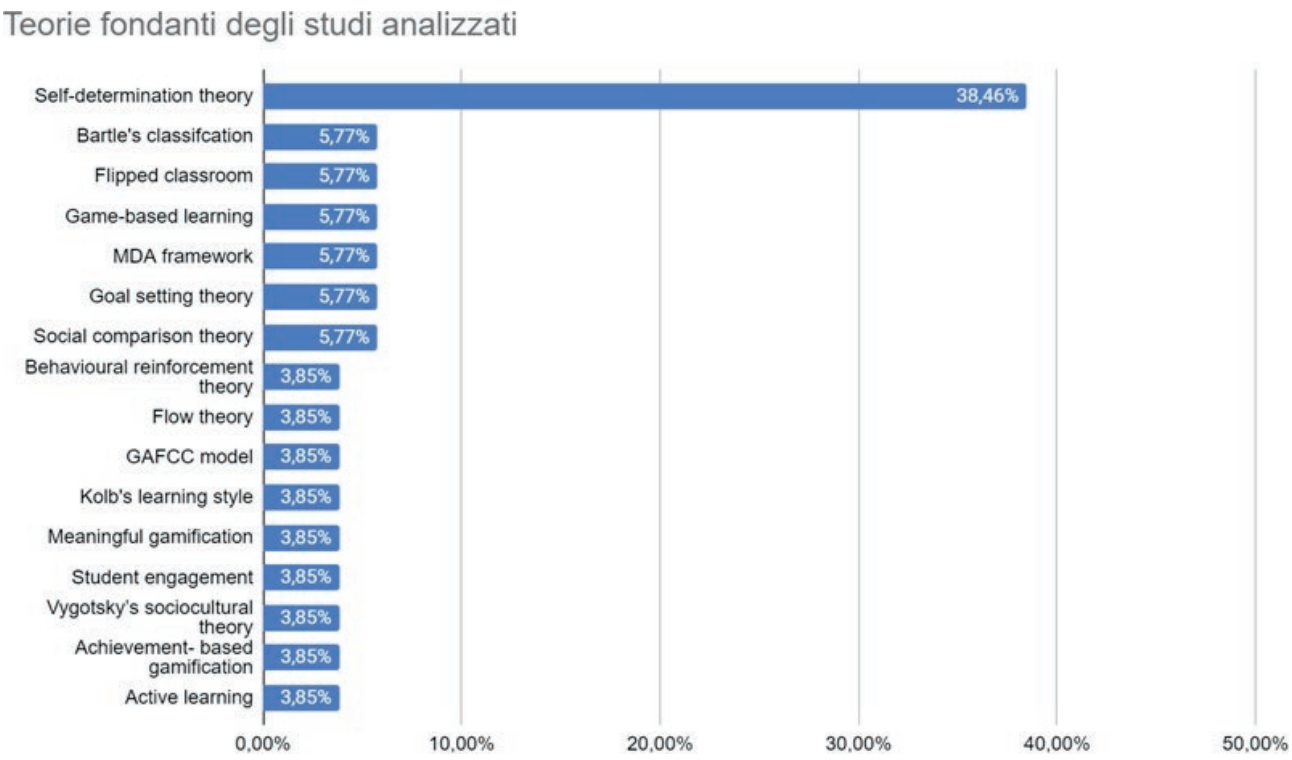

Figure 3. Founding theories.

into the intricacies of gamification's impact and functionality within the context of learning, providing a rich framework for understanding how gamification can be meaningfully employed to enhance educational experiences. On the other hand, with regard to student engagement and the value of active learning, considering the importance that the authors of its definition attribute to it in their articles, one would expect to find more studies in which these theories are cited and reported.

3.3. Research questions and hypotheses (RQ2)

Although the research hypotheses of the articles considered by our SLR are very different from each other, we are able to trace them back to a few macro-areas.

Almost one third (29%, N = 15) of the research questions referred to in the analysed articles focus on student engagement. The authors investigate whether the introduction of gamification or of two different modes of gamification increase student engagement. Other studies address research questions investigating whether student motivation increases through gamification. These studies are the 25% (N = 13) of the total number of retrieved papers. Another 23% of the studies (N = 12) investigate whether learning improve and whether, at the same time, performance in the pre- and post-tests or in the comparison with the control group is higher. 19% (N = 10) of the studies has to do with the achievement of the students' learning outcomes. Another significant proportion of the studies considered (13%, N = 7) investigate what the students' opinions of gamification are, either before/after attending a given course or only afterwards. In the next position, by a difference of just one percentage point, there are studies concerning, among others, participation: do students who take part in a

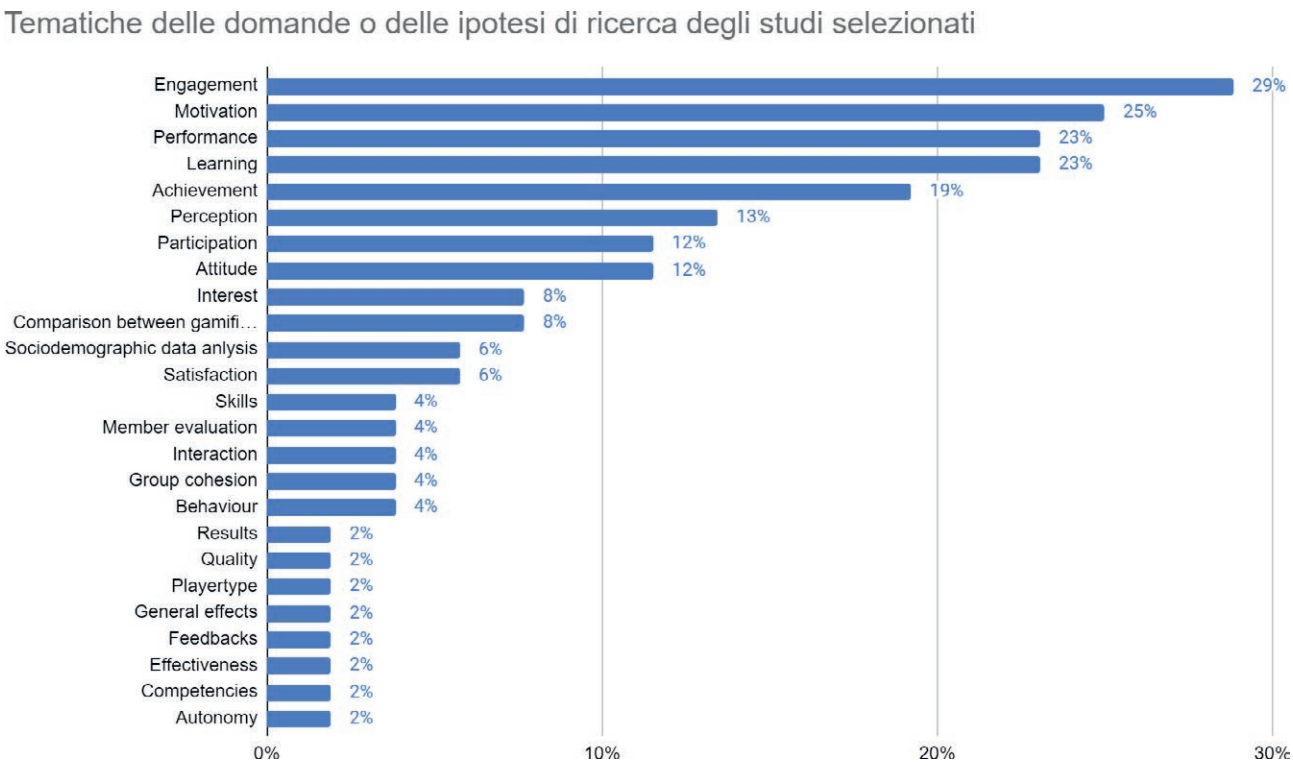

Figure 4. Research questions and hypotheses.

course in which gamification is included and participate more than students who take part in a traditional course?

Also in 12% (N = 6) of the cases, the researchers investigate what approach, behaviour, or position the students take towards gamification, and explore if and how this changes before and after the experimentation. 8% (N = 4) of the studies seek to understand whether the use of different types of gamification leads to the same outcome or whether, on the contrary, some are more suitable than others, depending on the intended purpose, in light of stimulating students differently or proving more suitable for certain types of courses or disciplines. A further 8% (N = 4) of the studies investigate whether the use of gamification leads to an increase in students' interest in the course they are following. In 6% (N = 3) of the bibliography considered, the following two aspects are investigated: satisfaction and the relationship between gamification and socio-demographic traits. Interestingly, some studies investigate whether gamification increases the satisfaction of the students taking the course, comparing the results between, before, and after the course or comparing the course group in which gamification is implemented to the control group. Other studies investigate whether the sociodemographic traits (age, gender, etc.) of the subjects exposed to gamification influence the result. Others investigate whether and how gamification increases students' abilities, while some hypothesize that implementing gamification during group work may yield beneficial outcomes. Moreover, there are articles and studies that question whether and how interactions between students (whether alone or in groups) change: some hypothesise that the cohesion of a group is stronger when working through gamification, while others investigate whether the behaviour of students participating in a gamified course improve or not.

This overview allows three reflections. The first concerns the actual usefulness of the implementation of gamification, especially enabling us to think about its possible impact on participation and motivation: since students are more stimulated, they participate more purposefully and are more motivated in higher education courses. The second reflection relates to satisfaction. This cannot only be analysed globally; however, the different gamification elements implemented must be thoroughly analysed. The third relates to those questions, which are not apparently adequately addressed in the scientific literature, i.e. 'if' and 'how' gamification improves students' skills. On this aspect, the only noteworthy study we found is the one conducted by Riar et al. (2022) on cooperative work and gamification; however, this is not entirely experimental.

3.4. Modes of implementation and duration (RQ2)

In total, 89% (N = 46) of the studies included in our SLR are implemented in university contexts and only 11% (N = 6) are used in post-graduate corporate training but managed by universities. Considering this data, we tried to analyse the learning modalities proposed by these studies: 58.5% (N = 31) of the studies apply gamification within face-to-face courses, while only 24.5% (N = 13) do the same in a blended mode. Finally, only 17% (N = 9) of the studies apply gamification within courses delivered entirely in an e-learning format. This is surprising because companies often conceive gamification precisely as an element to be implemented in self-training courses, thus using this approach to sustain the pace of training and spur people on towards completing their course. Instead, we found that the blended format is quite common, despite the scarcity and mainly empirical nature of studies linking blended learning and gamification (Tan & Hew, 2016). Certainly, blended approaches, with their presence-synchronous-asynchronous alternation, could in principle fit well with the gamification approach, allow students to value, and pay attention to all three learning phases, as well as to respect their specific cadence.

In line with our exclusion criterion, we eliminated all implementations lasting for only one lesson and/or less than three hours. Our subsequent analysis shows a varied picture: 53.1% (N = 26) of the studies manage to implement gamification for one semester, but only 12.2% (N = 6) manage to sustain its implementation over the entire academic year. Moreover, 12.2% (N = 6) of the studies implement gamification within a range of one to four weeks, while 8.2% (N = 4) studies implement it for five to eight weeks, and 6.1% (N = 3) studies implement it over nine to ten weeks. Finally, 6.1% (N = 3) of the studies produce a course that applies gamification for two consecutive years, while 2% (N = 1) concern longitudinal work over three years.

The overall picture makes us think first about the sustainability of gamification: being an approach that requires planning and design, implementing it for a long time is not always easy and sustainable.

3.5. Impacted factors (RQ3)

As per Figure 6, the factors mentioned in the retrieved studies as impacted by gamification, are many and varied: at first position, with 50% (N = 26), are performance and learning, while perception and satisfaction with gamification (48.08%, N = 25) are in second position, followed by motivation and engagement (36.54%, N = 19) and points, scores, and grades (36.54%, N = 19). Next come social and personality traits (26.92%, N = 14), along with attendance and participation (29.62%, N = 14), and then knowledge and skills (21.15%, N = 11), and scholastic aptitude (11.54%, N = 6). Of particular impor-

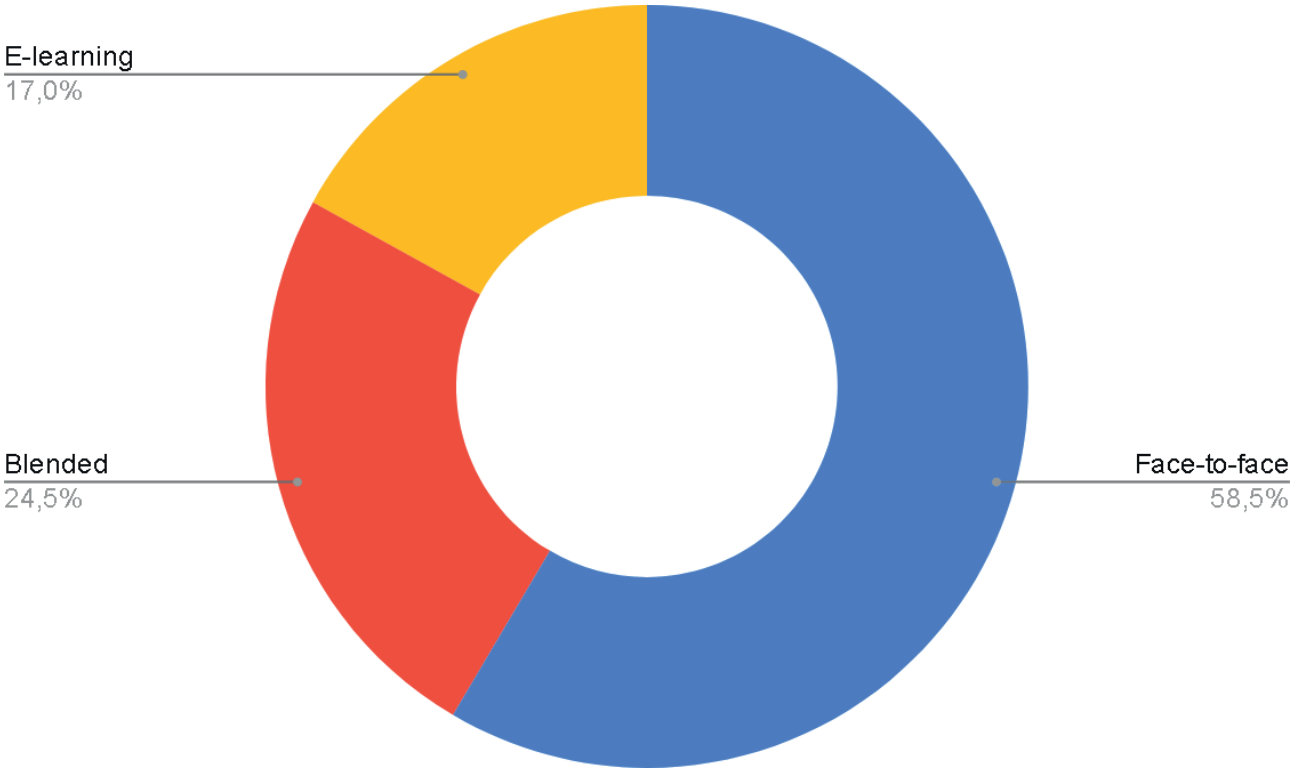

Figure 5. Implementation modes.

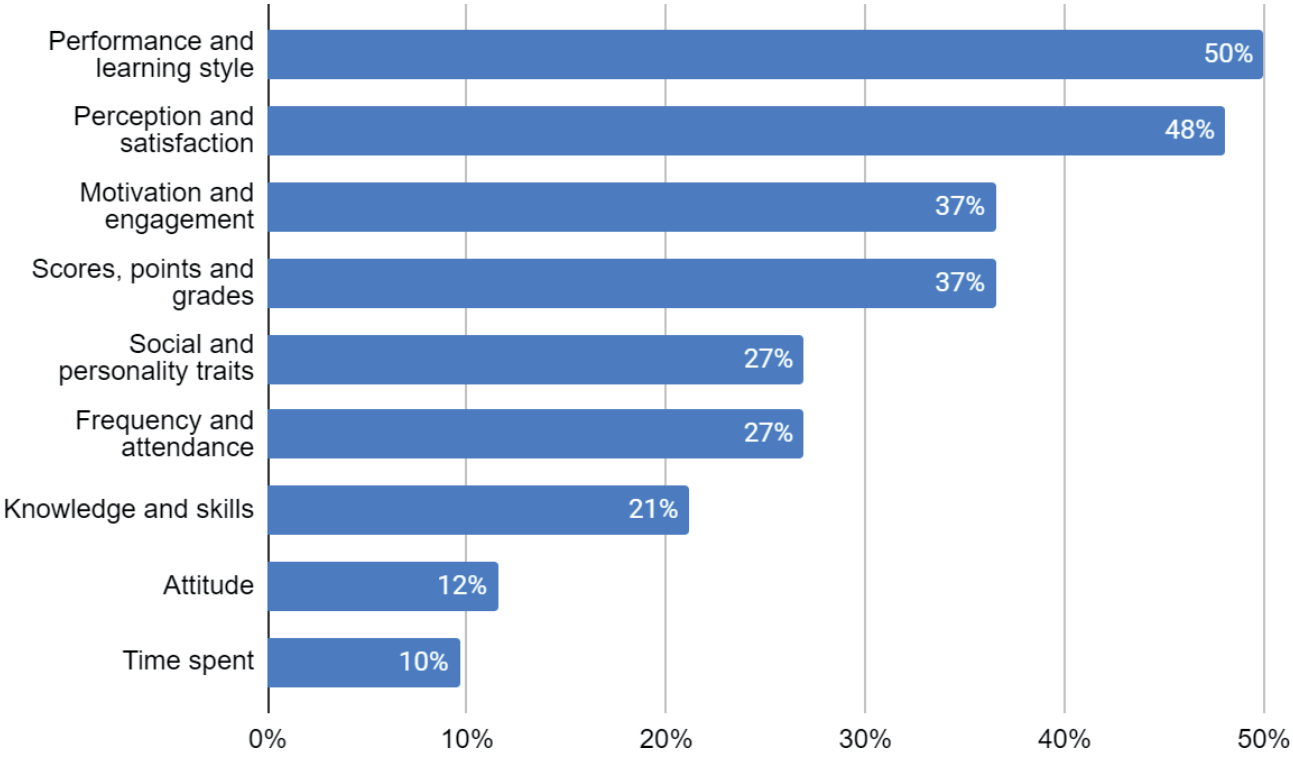

Figure 6. Impacted factors.

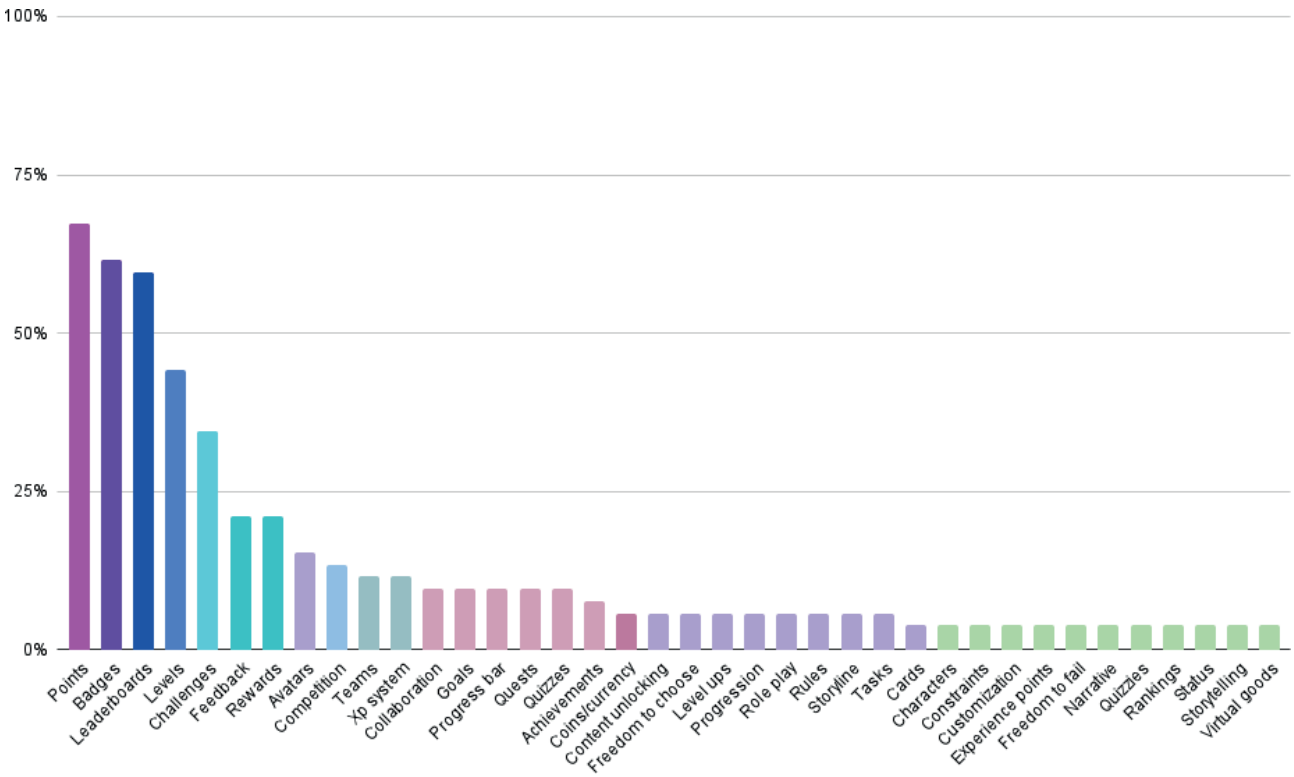

Figure 7. Elements of gamification.

tance is our finding regarding the impacts on social abilities (e.g. collaborative competence, ability to teamwork, and leadership) and on the knowledge and skills that gamification can achieve. Further, there are some studies that tried to investigate gender and age differences with regard to the impact of gamification, albeit without obtaining unequivocal results (Polo-Peña et al., 2021).

3.6. Elements of gamification (RQ3)

As seen from Figure 7, the majority of the experiments use the point's instrument as the favoured method to implement gamification. The assignment of points represents the method used by 67.31% (N = 35) of the considered studies (well over the halfway mark). Closely following the assignment of points is the use of badges (61.54%, N = 32). In third and fourth place, we find the leaderboard (59.62%, N = 31) and competitive levels (44.23%, N = 23). Other significant gamification elements also emerge, although they are reportedly used less frequently: challenges (34.62%, N = 18), feedback (21.15%, N = 11) and rewards (21.15%, N = 11).

Although the scoring may vary in terms of mode, most gamification experiences use it as a pivotal modality. Points can be awarded to assess delivery, assignments, collaboration, or participation, all in well-defined ways. Similarly, badges are also awarded to students in specific ways and can be earned in very different ways, e.g., by reaching a goal, or handing in or taking a material. In some experiments, secret badges are also awarded, i.e. badges that are not listed among the possible outcomes that students can achieve, and are used to reward and stimulate curiosity. Particular attention must be given to these elements, as in all the retrieved studies, the authors do not consider them completely positively: whether

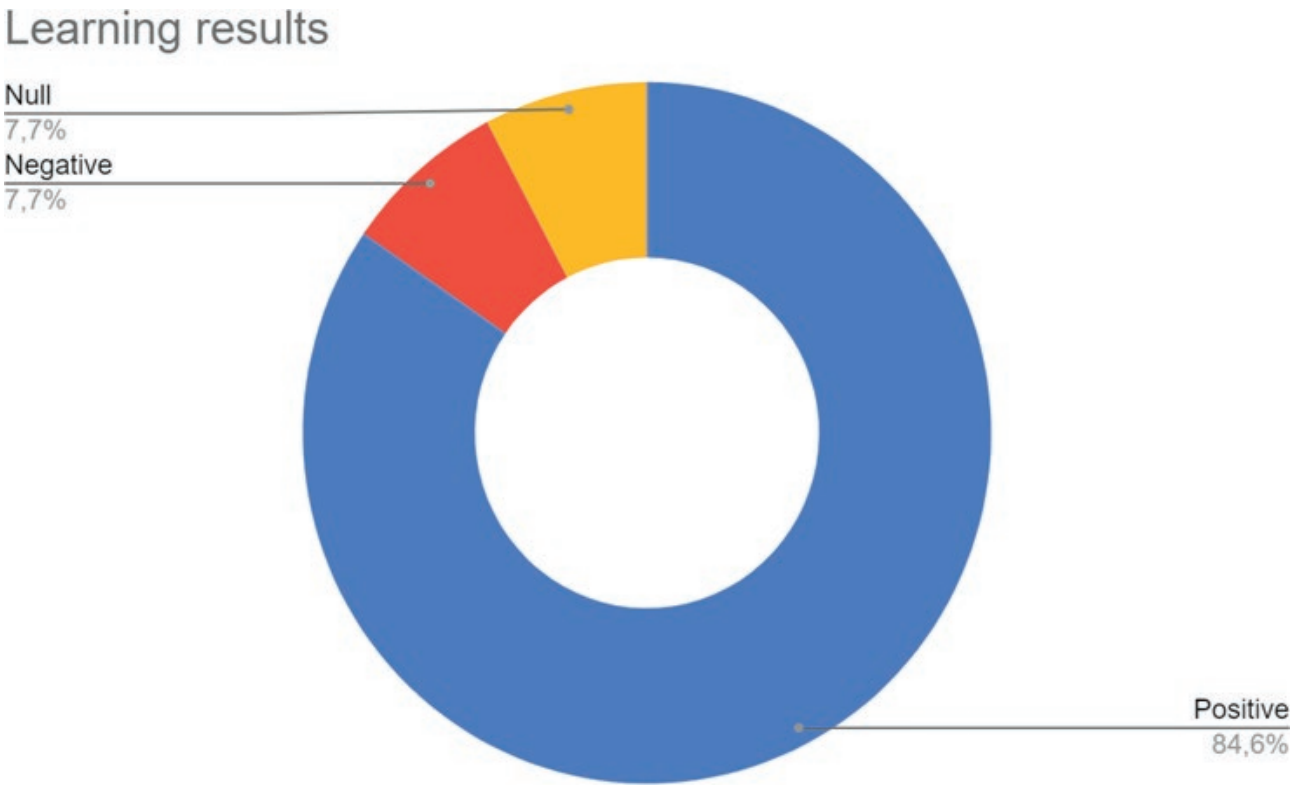

Figure 8. Learning outcomes.

they list all participants or only the top ten ones, they can turn out to trigger or decrease motivation. Moreover, a leaderboard can increase motivation in all students who want to challenge for top positions or who, in general, feel stimulated to compete; however, it can become a source of demotivation for those who fail to emerge or for those who experience competition negatively (Dyjur & Lindstrom, 2017; Stefaniak & Carey, 2019). Undoubtedly, the incorporation of the challenge-feedback-reward mechanism stands out as the quintessential embodiment of the MDA (Mechanics, Dynamics, and Aesthetics) system, establishing itself as a fundamental cornerstone that profoundly influences the successful integration of functional gamification within the literature being examined. This strategic adoption not only encapsulates the very essence of the MDA system but also underscores its pivotal role in orchestrating a cohesive and engaging gamified experience. By leveraging the challenge-feedback-reward mechanism, this approach strategically aligns the mechanics, dynamics, and aesthetics of the gamification design, creating a symbiotic relationship that enhances user engagement and immersion. It serves as a unifying force, seamlessly weaving together the interactive elements of challenges, responsive feedback, and enticing rewards, thereby contributing to a well-balanced and compelling gamified environment.

3.7. Learning outcomes (RQ3)

As from the following figure, in our analysis the majority of the studies (84.6%, N = 43) report positive results, thus confirming the hypotheses put forward by the respective authors. There is an insignificant percentage (7.7%, N = 4) of studies in which the research questions do not receive relevant support from the collected data, or in which no differences are noted among the outcomes before

students' exposure to gamification and those after their exposure to gamification, or there are no differences between study groups and control groups. All these studies have been assigned a null in this SLR (see figure). A third group of studies answered negatively to their research questions /hypotheses because of their experiments; again, however, this group constitutes a very small part (7.7%, N = 4) of the total number of cases analysed.

Some studies point to negative consequences when the environment becomes competitive and this turns out to be unhealthy, or when there are situations in which male and female students aim exclusively at winning instead of learning. There are also studies which point out that without the right balance between content and gamification, the encouraging results previously underlined are not achieved, since not all participants find gamification fun or stimulating and there may be differences in reactions according to gender, age, character (introverts and extroverts have very different characteristics), frequency, or mode of approach to the game/videogame. Furthermore, there are scholars who point out the impacts on particularly introverted people and others who simply do not notice any difference in their experiments between groups exposed to gamification and control groups.

4. Thematic analysis results

This section aims to consolidate the SLR results through a thematic analysis of the included articles. The aim of a section is to extract and group the studies thanks to a thematic analysis (Braun & Clarke, 2006) to provide a conceptual map of the relationships among themes. One of the tools on which we have relied to complete the thematic analysis is the "meta-summary", especially the results that this has returned us. We calculated the frequency and intensity for each theme, indicating the number of studies with similar results and the concentration of results within the same study. Themes were identified inductively, starting from the data obtained from the articles considered.

4.1. Keywords chosen by the authors

The keywords chosen by the authors are a fundamental aspect, as they should reflect the main topics / concepts addressed in the studies according to their respective authors. In Figure 9, the distribution of the keywords is shown.

Obviously, the most-used keyword is 'gamification'. 'Motivation' is the second-most used keyword (13.4%, N = 7), followed by 'higher education' (11.5%, N = 6), and 'engagement' (9.62%, N = 5). Notably, 'game elements' and 'teaching strategies' share the same percentage level in terms of usage (7.6%, N = 4). 'Teaching strategies' is commonly used to describe implemented game elements or gamification itself, although gamification transcends a mere strategy, representing a distinct methodology with specific design elements. Terms like 'e-learning' or 'blended learning' have a lower level of occurrence (5.7%, N = 3).

4.2. Emerging themes

Before categorising the articles, we tagged each article with sub-themes so that every article has from one to three different nominal tags. The picture of the emerging themes proposed by us (Figure 10) is slightly different from the one coming from the keywords proposed by the authors of the retrieved paper (see Section 3.1).

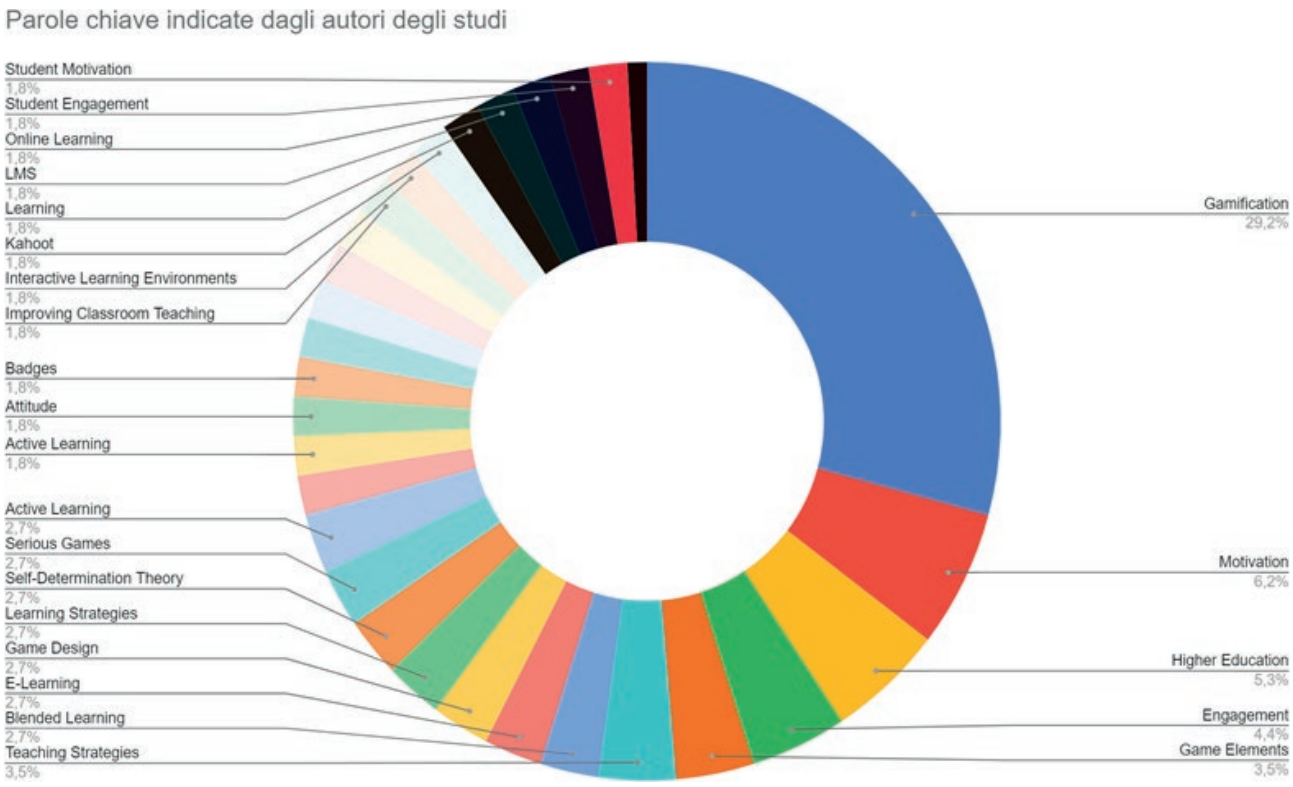

Figure 9. Keywords.

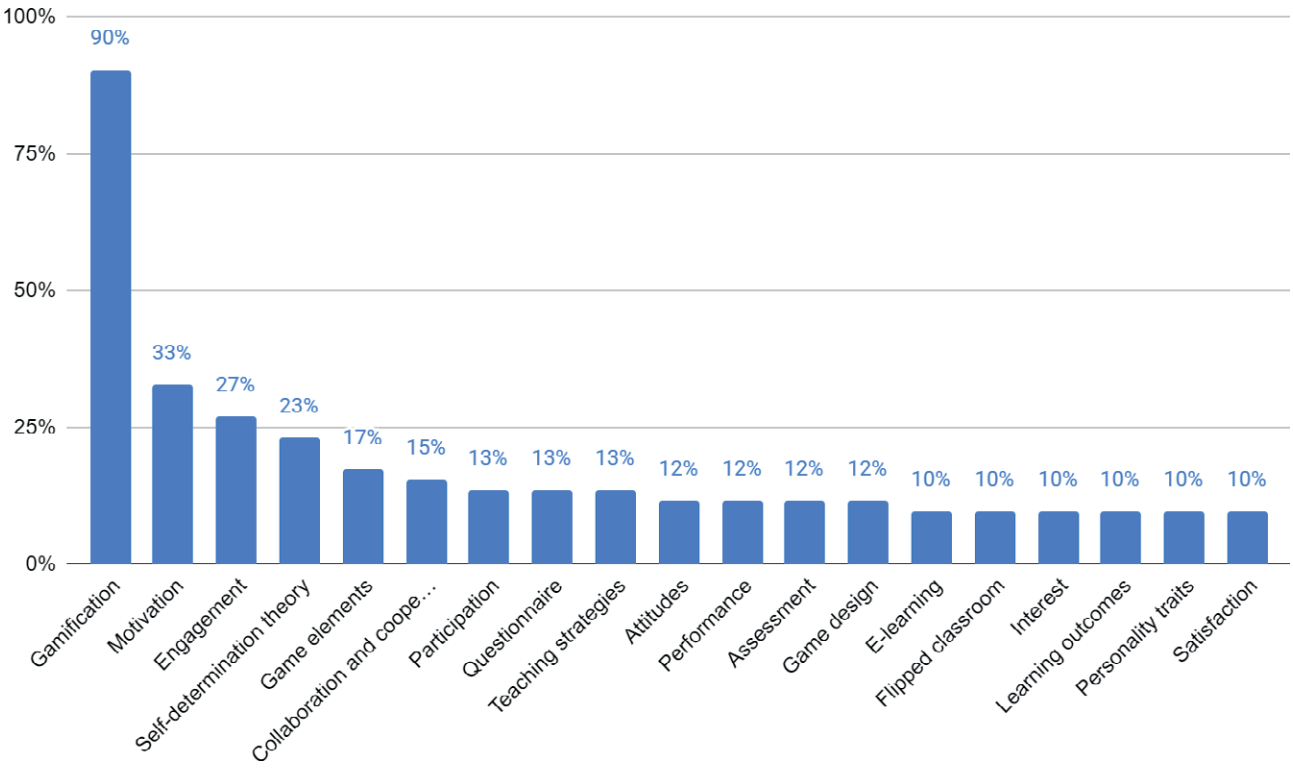

Figure 10. Emerging themes.

We can state that the theme 'gamification' is the most common in the articles selected for the SLR (90.38%, N=47). The term is followed by 'motivation' (32.69%, N = 17), 'engagement' (26.92%, N = 14), and 'self-determination theory' (SDT) (23.1%, N = 12). Once again, it is evident that gamification in higher education is perceived as a means to boost motivation, enhance student engagement, and encourage participation. Notably, the theme of SDT is significant, being often explored in studies concerning students' autonomy in choosing gamification activities. Some studies evaluate the skills acquired or relationships developed through gamification. Overall, the above figure illustrates that the 'gamification' theme constitutes 16.4% of all keywords, with subsequent themes – 'motivation', 'engagement', 'self-determination theory', and 'participation' – following with lower percentages of 6.7%, 5.5%, 4.7%, and 2.7%, respectively, in terms of their intensity relative to the entire set of themes.

4.3. Emerging statements

The emerging themes coming from the nominal tags presented in the previous section, was then broken down into 11 significant 'statements' repeated across the various considered studies.

Table 3 details the frequency and intensity emerging from the retrieved articles. This classification takes into account the possibility of associating more than one statement with one paper. The statement that is mostly associated with papers (N=30) is "Better performances through gamification", while those that are the least associated (N=4) are "Improving gamification from feedbacks" and "Comparison between different types of gamification". The column 'Percentage frequency' was calculated relative to the total number of studies considered (N=53), the column 'Percentage intensity' was calculated relative to the total frequency of the themes themselves (N=139).

According to the table, it seems the greatest interest lies in increasing student performance: more than half of the articles (57.69%, N = 30) address it; in fact, this corresponds to 21.6% of the recurrence of the statements. This is followed by the increase in participation (with a frequency in articles of 48.07% [N = 25] and an intensity of 17.9%), better learning (with a frequency in articles of 38.46% (N = 20) and an intensity of 14.3%), and more motivation (with a frequency on articles of 23.07% (N = 12) and an intensity of 11.5%). We observe that the division into statements is in line with what emerges in the section on keyword analysis and indeed confirms the scientific literature on the subject.

5. Conclusions

This SLR focuses on the implementation of gamification in higher education and addresses the proposed research questions with the aim to better understand the state of the art in the sector. This study helped to identify the following open issues:

- The first relates to the fact that we retrieved studies that analyse the topic uniformly at the theoretical level, but not at the empirical level.
- The second relates to the elements that can be implemented in a gamification course. Since they are highly varied and quite different from each other, the teacher and researcher can exercise discretion over which elements to implement and for which teaching purposes, thus making gamification adaptable and flexible for individual needs.
- The third relates to the other side of the coin: such flexibility and adaptability of gamification so far has not yet allowed the definition of any functional and working model for gamification at the higher-education level.

Table 3. Emerging statements (Frequency and intensity).

Statement	Frequency	Percentage frequency	Percentage intensity
Better performances through gamification	30	57.69%	21,58%
More participation through gamification	25	48.07%	17,99%
Better learning through gamification	20	38.46%	14,39%
Students' perceptions on gamification	16	30.77%	11,51%
More motivation through gamification	12	23.07%	8,63%
Personal influences of students on gamification results/attitudes	11	21.15%	7,91%
Better behaviour/interaction of students	9	17.31%	6,47%
Examination of student attitudes	6	11.54%	4,32%
More satisfaction in students	4	7.69%	2,88%
Improving gamification from feedbacks	3	5.77%	2,16%
Comparison between different types of gamification	3	5.77%	2,16%
Total	139	/	100%

Concluding this systematic literature review, it is evident that the integration of games into college education is a multifaceted endeavour. However, it is crucial to acknowledge the inherent limitations of this comprehensive examination. Firstly, the extant literature may not encompass every facet of gamification in higher education, and the dynamic nature of both educational practices and technology implies that newer developments may emerge post-review. Additionally, the heterogeneity in methodologies across the examined studies may pose challenges in synthesizing conclusive insights.

While this review provides valuable insights into the theoretical underpinnings and practical applications of gamification in higher learning, the practical implementation of these findings demands careful consideration of contextual factors, institutional dynamics, and evolving pedagogical paradigms. The transition from theory to practice necessitates a nuanced approach, acknowledging the diverse educational landscapes and adapting gamification strategies accordingly.

Looking forward, the future research agenda should focus on bridging the gap between theory and practice in gamified education. This involves not only refining theoretical frameworks, but also delving into the real-world implications of gamification within varied academic settings. Moreover, efforts should be directed towards establishing robust methodologies for assessing the effectiveness of gamification in higher education. This entails developing comprehensive metrics, innovative tracking mechanisms, and longitudinal studies to gauge the long-term impact on student learning outcomes.

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The effect of peer assessment on translation performance among EFL students at various achievement levels

L'impatto della valutazione tra pari sulla qualità delle traduzioni in studenti d'inglese come lingua straniera con differenti livelli di rendimento

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ABSTRACT The purpose of this study was to examine the impact of peer assessment on learning and motivation of students at different achievement (low, average, and high) levels. Forty-one English-as-foreign-language (EFL) students were invited to participate in this study. All students completed an English translation project, then participated in a peer assessment activity to read and comment upon each other's work. Afterward, students revised and resubmitted their own translation projects. Data analysis suggested that the peer assessment activity integrated in this study significantly promoted all students' performance (in terms of increased points between the first version and the second version of students' submissions) on the English translation project, notwithstanding students' achievement levels. Comparisons of students' initial translation projects (before peer assessment) and final translation projects (after peer assessment) revealed that low-achieving students had the greatest degree of improvement, followed by average- and then high-achieving students. Nevertheless, all students reported that they enjoyed the peer assessment activity and put forth comparable effort, as measured by the Enjoyment and Effort subscales. Interpretation of the results and implications were discussed.

KEYWORDS Peer Assessment; Achievement Levels; Motivation; English-as-Foreign-Language (EFL).

SOMMARIO L'obiettivo di questo studio è stato quello di esaminare l'impatto della valutazione tra pari sull'apprendimento e sulla motivazione degli studenti a diversi livelli di rendimento (basso, medio e alto). Quarantuno partecipanti, tutti studenti di inglese come lingua straniera (EFL), sono stati invitati a partecipare a questo studio. Tutti hanno completato un progetto di traduzione in inglese, partecipando in seguito a un'attività di valutazione tra pari, leggendo e commentando il lavoro degli altri. Successivamente, gli studenti hanno rivisto e ripresentato i propri progetti di traduzione. L'analisi dei dati suggerisce che l'attività di valutazione tra pari ha migliorato in modo significativo le prestazioni di tutti gli studenti nella traduzione (in termini di aumento dei voti tra la prima e la seconda versione), indipendentemente dai loro livelli di rendimento. Il confronto tra le traduzioni iniziali degli studenti (prima della valutazione tra pari) e quelle finali (dopo la valutazione tra pari) ha rivelato che gli studenti con risultati bassi hanno avuto il maggior grado di miglioramento, seguiti da quelli con risultati medi e poi da quelli con risultati alti. Ciononostante, tutti gli studenti hanno dichiarato di aver apprezzato l'attività di valutazione tra pari e di essersi impegnati in modo analogo, come misurato dalle scale di gradimento e di impegno. L'interpretazione dei risultati e le implicazioni vengono discusse nel contributo.

PAROLE CHIAVE Valutazione tra Pari; Livelli di Rendimento; Motivazione; Inglese come Lingua Straniera (EFL).

1. Literature review

1.1. Overview of peer assessment

Peer assessment is a process in which students evaluate the work of their peers and provide feedback using performance criteria (Falchikov, 2007). The use of peer assessment has shown significant growth over the last two decades. The literature reports that peer assessment has been utilized in various disciplines, including teacher education (Li, 2011; Lynch, McNamara, & Seery, 2012), physics (Handayani & Genisa, 2019), computer science (Wang, Li, Feng, Jiang, & Liu, 2012), art education (Liu, Wan, Tu, Chen, & Wang, 2021), medicine education (Violato & Lockyer, 2006), engineering (Hersam, Luna, & Light, 2004), foreign language acquisition (Cheng & Warren, 2005; Hung, 2018), biology (Orsmond, Merry, & Reiling, 1996), and business (Brutus, Donia, & Ronen, 2013, Tiew, 2010). As a learning tool, peer assessment has demonstrated positive effects on student academic achievement, cognitive growth, and other learning or developmental outcomes (Li & Gao, 2016). After an extensive review of peer assessment studies in higher education, Topping (1998) reaches a conclusion that peer assessment may "*yield gains in the cognitive, social, affective, transferable skill, and systemic domains that are at least as good as those from staff assessment*" (p. 269). A more recent meta-analysis of 58 peer assessment studies (Li, Xiong, Hunter, Guo, & Tywoniw, 2020) confirms that peer assessment helps students improve their performance. The researchers further report that computer-assisted peer assessment generates greater learning gains than paper-based peer assessment. The literature suggests that these "learning gains" may include:

- Enhancing students' autonomy, motivation (Brown, 2004; Hiltz & Wellman, 1997; Pope, 2001), course attendance (Deslauriers, Schelew, & Wieman, 2011), and engagement (Handayani & Genisa, 2019; Lucas, 2009).
- Promoting student responsibility (Somervell, 1993).
- Fostering students' critical thinking skills (Zhan, 2021).
- Encouraging interpersonal skills among students (Dochy, Segers, & Sluijsmans, 1999; Patri, 2002).
- Deepening students' understanding of assessment criteria and quality performance (Dochy et al., 1999).
- Improving quality of work (Li & Steckelberg, 2005; Liu et al., 2021; Pope, 2001) and learners' conceptual understanding (Duncan, 2005).
- Supporting collaborative online learning (Zou, Xie & Wang, 2021).

Despite its growing popularity and documented potential, peer assessment is not a strategy without drawbacks. Some of these pitfalls include peer pressure and student assessment skills (Li & Gao, 2016). Take peer pressure as an example, Robinson states (1999, p. 96) that when students assess each other, "*marking could be easily affected by friendship, cheating, ego or low self-esteem.*" This problem is especially prominent in paper-based peer assessment when it is difficult to protect the anonymity of assessors and assessees. The other issue relates to students' ability to conduct valid and valuable assessment of peers' work. The traditional role of a student is a learner who is usually being assessed and rarely assesses others. Switching students' roles from assessee to assessor is generally difficult and may require assistance, such as assessment training, to get students prepared (Li & Gao, 2016).

1.2. Peer assessment and student achievement levels

It remains unclear what makes effective peer assessment (Li & Grion, 2019; Van Zundert, Sluijsmans, & Van Merriënboer, 2010). In the handful of studies that lend insight into the "how students

learn" aspect of peer assessment, Davies (2000) noted that the peer assessment activity in his study had a disproportionate impact on students. Comparing students' test scores before and after the peer assessment process showed that students at higher achievement levels benefited the least from the process (by gaining the smallest increase from their pre- to post-report scores), while students at lower achievement levels benefited the most (by gaining the biggest increase from their pre- to post-report scores). This captivating but incidental observation was supported, to some extent, by two later studies (Li, Steckelberg, & Srinivasan, 2008; Li, 2011). One study (Li et al., 2008) explored student perceptions toward peer assessment. While students' attitudes were generally positive toward peer assessment, one high-achieving student stated that, "*sometimes peer assessment isn't helpful if you already did a good job*" (p. 143). The other study (Li, 2011), with a descriptive and qualitative approach, examined the impact of peer assessment on the work of students at different achievement levels. Their discovery was in line with the studies discussed above that peer assessment seemed to benefit students in the early academic development stages more than students at more advanced achievement levels.

As intriguing as these observations were, they were either incidental, or from qualitative or descriptive analyses, which bear the limitation that the knowledge gained from these studies may not be generalized beyond the specific samples of these studies. To circumvent the limitation, Li and Gao (2016) took the investigation one step further and used a two-way factorial design to investigate how peer assessment interplayed with student achievement levels to impact student learning. One hundred and thirty undergraduate students were assigned into either an experimental group or a control group working on a technology-integrated lesson plan. While students in the control group used a traditional discussion approach to improve their lesson plans, students in the experimental group reviewed peers' projects and provided feedback to help each other improve their own projects. Based on the scores of the students' first draft lesson plans, students in each group (control or experimental) were divided into three levels: low, average, and high achieving. The comparisons of the students' final lesson plan scores in both groups suggested that the peer assessment group outperformed the control group on their lesson plan project scores. Data analysis also indicated a joint influence of peer assessment and student achievement levels on the quality of their lesson plan projects. More specifically, the findings were in agreement with other studies by showing that low- and average-achieving students reported a bigger learning gain than high-achieving students.

While encouraged by the confirmed benefits of peer assessment on student learning, the researchers (Li & Gao, 2016) noted a possible measurement limitation in their study: the ceiling effect. They speculated that the ceiling effect may explain the findings of the limited learning gain of high-achieving students in their study. Specifically, the researchers speculated that that "*…high achievers' scores were close to the maximum score on the lesson plan project, which may have created a ceiling effect and may have decreased the likelihood that the rubric had accurately measured learning gains of high achievers. In other words, high achievers may simply have not had enough room to demonstrate their improvement.*" According to Cramer and Hotwitt (2004), "*failure to recognize the possibility that there is a ceiling effect may lead to the mistaken conclusion that the independent variable has no effect*" (p. 21). The current study aims to address the possible ceiling effect issue by increasing the difficulty level of the project for students to complete in a peer assessment activity, so most students will not be able to score near or close to the maximum score. To attain this goal, the researchers purposefully identified an English translation activity in which students could employ peer assessment to improve their scores.

1.3. Peer assessment in translation instruction

Researchers and educators in the translation field have long noticed that the traditional teacher-centered translation classes do not motivate or inspire students (Colina, 2003; Davis, 2005; Kiraly, 1995; Kiraly, 2000) and have been exploring ways to actively engage students in learning. Although peer assessment has been well studied in second or foreign language writing and speaking instruction (Rollinson, 2005; Chien, Hwang, & Jong, 2020; Shen, Bai, & Xue, 2020), only a handful of researchers examined the effects of peer assessment in translation instruction (Wang & Han, 2013; Huynh & Nguyen, 2019; Lin, Song, Guo, & Wang, 2021). These studies revealed that students viewed peer assessment as positive (Wang & Han, 2013; Huynh & Nguyen, 2019), were motivated during the process (Huynh & Nguyen, 2019), and acknowledged an improvement in their translation skills (Wang & Han, 2013; Huynh & Nguyen, 2019). Studies also suggested that peer-assessment-based translation activities engaged students in collaborative learning (Insai & Poonlarp, 2017; Lin, Song, Guo, & Wang, 2021), offered students different perspectives on solving problems in their translation (Wang & Han, 2013; Huynh & Nguyen, 2019), empowered students in their learning, and fostered critical thinking (Wang & Han, 2013). The findings suggest that there is value in integrating peer assessment into translation instruction and that students with various achievement levels are impacted in different ways, as discussed above. However, there are still questions left unexplored. In particular, it is unclear whether peer assessment has an equal impact on students' performance regardless of students' achievement levels, or what instructors should do to accommodate students with different achievement levels in peer-assessment-based translation activities.

1.4. Purpose statement and research questions

The current study will contribute to the existing research literature in two ways. First, the study will add to the peer assessment research by addressing the ceiling effect in the previous study (Li & Gao, 2016). The researchers believed that the translation project was at an appropriate difficulty level, and it would be unlikely for most students to achieve very high scores in their initial drafts before peer assessment. Second, the study will add to the limited research on how to improve translation instruction through peer assessment. In light of the literature, the current study seeks to answer three research questions:

1) Are there statistically significant differences in learning gain in terms of increased grades (from the initial version to the final version of a student English translation project) in a peer assessment activity between students at low-, average-, and high-achieving levels in a translation class?
2) Are there statistically significant differences in student self-reported enjoyment during a peer assessment activity between students at low-, average-, and high-achieving levels in a translation class?
3) Are there statistically significant differences in student self-reported effort put forth during a peer assessment activity between students at low-, average-, and high-achieving levels in a translation class?

2. Methodology

2.1. Participants and settings

Forty-one undergraduate students (6 males and 35 females) at a university in southeast China were invited to participate in this study. All participants were English majors and were enrolled in two sec-

tions of an English translation class. The two class sections were taught by the same instructor, using the same curriculum. Of those reported, the students' ages were between 19 and 21 with a mean of 20.6.

This study was approved by the IRB (Institutional Review Board) at Bowling Green State University (ID: 978720-3). Students were invited to attend an information session to learn about the research project and understand their rights as human subjects. Only students who signed the consent form were invited to participate in this study.

2.2. Procedure

In the three-week-long lesson plan module, all students completed an assignment of translating a passage of about 450 Chinese characters into English. The translation task was intentionally designed to be moderately challenging to eliminate the possibility of too many low or high scores in students' initial drafts. The researchers anticipated that this approach would mitigate the potential ceiling effect. After students completed their first draft translation, they followed the peer assessment procedure. In week 1, students submitted their work to an online document collaboration site, called Shimo (https://shimo.im/) (initial submission). A cloud-based productivity tool called Shimo Document was deliberately selected to enhance and facilitate the peer assessment process. Shimo offers a range of features to accelerate collaboration and online document editing. Similar to Google Dos, this platform supports multi-end synchronization and allows users to create, edit, and share documents in real-time.

All students received training on how to evaluate peer projects and provide feedback. Students were instructed that the project rubric should be considered when they provide feedback to peers. Feedback should be backed up by the rubric. In week 2, each student was randomly assigned to review and comment on five or six translation submissions from peers within Shimo. Each student posted at least two comments to each assigned work and also responded to their classmates' comments on their own work. At this stage, the students were instructed that they did not have to blindly follow suggestions or comments from peers. The students understood, from the previous training, that the quality of peer feedback varied. They were strongly encouraged to evaluate the quality of peer feedback with a reference to the rubric and only adopt suggestions that they deemed correct. In week 3, students revised their translation work based on their classmates' comments and their reflections on their classmates' work (final submission). Students then completed a survey that included statements to measure their enjoyment and effort put forth in the peer assessment activity.

2.3. Data collection and analysis

2.3.1. Student learning

The researchers looked at learning gain in terms of increased grades from the first-round project grade to the second-round project grade. The instructor graded all the submissions using a translation evaluation rubric (see Table 1), and a score ranging from 0 to 10 was assigned to each student's work. Decimal scores were allowed for grading. For example, a student's essay score could be 7.6 out of 10. To ensure the reliability of grading, the course instructor and a second rater worked together to grade 25% of randomly selected assignments. They first reviewed and discussed the rubrics to reach a common understanding of grading criteria. Next, they independently graded ten randomly selected assignments based on the rubrics. Then, they compared their gradings and resolved the disagreements through discussion. To determine the agreement between two raters, the researchers computed the

percent of exact or adjacent agreement (within 1 point) between the two grading sets. The percentage of exact agreement was 45.00%, while the percentage of adjacent agreement was 95.00%, which suggested a good level of consensus (Jonsson & Svingby, 2007; Stemler, 2004).

2.3.2. Student motivation

To measure student enjoyment and effort levels in the peer assessment activity, this study used two subscales from the Intrinsic Motivation Inventory (IMI) (Ryan, 1982). The IMI has been tested as reliable and valid (McAuley, Duncan, & Tammen, 1989), and has been extensively adopted to gauge student motivation, especially in technology-enabled learning environments (Bertacchini, Bilotta, Pantano, & Tavernise, 2012). Two subscales, Enjoyment and Effort, were selected in this study to measure students' perceptions in the peer assessment activity. Both subscales are rated on a 7-point Likert scale ranging from 1 (not at all true) to 7 (very true). The Enjoyment subscale consists of six items measuring students' self-reported intrinsic motivation. Example items include "*I thought this activity was quite enjoyable*," and "*This activity was fun to do*". The Effort subscale consists of five items that gauge the effort students put forth to complete the peer assessment project. Items include "*I put a lot of effort into this,*" and "*I didn't try very hard to do well at this activity*". Reverse coding was applied for negatively framed statements.

Table 1. Student translation evaluation rubric.

Categories	Criteria
Excellent 9-10 points	The translation faithfully reflects all of the original passage with only 1 or 2 minor errors in vocabulary, syntax, punctuation or spelling. The translation is elegant (appropriate choice of words, a variety in sentence patterns).
Good 7-8 points	The translation reflects almost all the original passage with relatively few significant errors of vocabulary, syntax, spelling or punctuation. The translation is readable (generally clear, smooth and cohesive).
Acceptable 5-6 points	The translation adequately reflects most of the original passage with occasional errors of vocabulary, syntax, spelling or punctuation. The translation is, for the most part, readable.
Inadequate 3-4 points	The translation only reflects about half of the original passage with frequent errors of vocabulary, syntax, spelling or punctuation. The translation is, in some parts, unreadable.
Poor 1-2 points	The translation reflects less than half of the original passage. Almost all sentences contain errors of vocabulary, syntax, spelling or punctuation. The translation is, for the most part, unreadable.

3. Results

3.1. Degree of Improvement in revised translation project

Research Question 1: "*Are there statistically significant differences in Improvement score (change of score from the initial version to the final version of a student English translation project) after a peer assessment activity between students at low-, average-, and high-achieving levels in a translation class?*"

A one-way ANOVA was conducted to determine if the degree of improvement (Improvement score) from the initial versions of the students' translation project to the final versions was different for groups at different achievement levels. Participants were assigned to three levels based on the scores of their initial versions of the project and their TEM-4 (Test for English Majors, Band-4) scores: low achieving (n = 15), average achieving (n = 14), and high achieving (n = 12). TEM-4 is a required national standardized test to measure English proficiency of English major undergraduate students in

China. The test was taken at the end of the sophomore year, before students participated in this study. TEM-4 is generally considered a reliable and valid test of student English proficiency (Jin & Fan, 2011). A test validation study (TEM Test Center, 1997, p. 63) suggested that "*the TEM tests are reasonably reliable and valid tests that are set at an appropriate (difficult) level as defined in the test specification*".

A few assumption tests were conducted to determine if it would be appropriate to use one-way ANOVA to answer the first research question. Boxplot suggested no outliers in the data. Data were normally distributed for each group, as assessed by Shapiro-Wilk test ($p > .05$). Levene's test of homogeneity of variances ($p = .161$) indicated that there was homogeneity of variances.

Data are presented as mean ± standard deviation. The Improvement score that measures the difference between the initial submission score and the final submission score of the student English translation project decreased from the low-achieving (1.90 ± 0.66) to the average-achieving (1.71 ± 0.51), and to the high-achieving (1.17 ± 0.44) level, in that order. As Table 2 shows, the Improvement score was statistically significantly different for different achievement levels, $F(2, 38) = 6.16$, $p < .005$. Tukey post hoc analysis revealed that there was a decrease in the Improvement score from the low-achieving group to the high-achieving group, with a decrease of 0.73 ± 0.21 [mean ± standard error], which was statistically significant ($p = .004$). In addition, there was a decrease in the Improvement score from the average-achieving group to the high-achieving group with a decrease of 0.55 ± 0.22 [mean ± standard error], which was also statistically significant ($p = .042$). However, the group difference between low achieving and average achieving was not statistically significant.

Table 2. One-Way Analysis of Variance of Improvement Score by Student Achievement Levels.

Source	df	SS	MS	F	p
Between Groups	2	3.77	1.88	6.16	.005
Within Groups	38	11.62	0.31		
Total	40	15.39			

Note: df = degree of freedom; SS = Sum of Squares; MS = Mean Square.

3.2. Motivation Scales

A one-way multivariate analysis of variance (MANOVA) was initially considered to determine the effect of peer assessment on student attitudes. Two measures of student attitudes were assessed: self-reported Enjoyment score and Effort score. Students were from three achievement levels: low-, average-, and high-achieving levels.

The Pearson Correlation showed negligible correlation ($r = 0.178$, $p=.265$) between the two dependent variables: Enjoyment score and Effort score. Although the Pearson Correlation showed no evidence of multicollinearity, the correlation suggested that the MANOVA test was not suitable to determine the effects of peer assessment on the two dependent variables, as the dependent variables should be moderately correlated in MANOVA (Laerd Statistics, 2015; Salkind, 2010). Salkind further states, "*If there is no correlation at all, MANOVA offers no improvement over an analysis of variance (ANOVA).*" Therefore, the researchers decided to run two separate ANOVAs to determine the impact of peer assessment on students' Enjoyment and Effort scores.

Research Question 2: "*Are there statistically significant differences in Enjoyment score after a peer assessment activity between students at low-, average-, and high-achieving levels in a translation class?*"

A one-way ANOVA was conducted to determine if the self-reported Enjoyment score was different for different levels: low achieving (n = 15), average achieving (n = 14), and high achieving (n = 12). Assumption tests showed that there were no outliers, as assessed by boxplot; data was normally distributed for each group, as assessed by Shapiro-Wilk test (p > .05); and Levene's test of homogeneity of variances (p = .952) indicated homogeneity of variances. Data is presented as mean ± standard deviation. As Table 3 shows, the Enjoyment score varied from low achieving (31.53 ± 5.17) to average achieving (30.79 ± 5.42), to high achieving (32.33 ± 5.14), in that order, but the differences between these achievement levels were not statistically significant, F(2, 38) = 0.281, p = .757.

Table 3. Means and Standard Deviations for Low-Achieving, Average-Achieving, and High-Achieving Levels on the Students' Enjoyment and Effort Scores.

	Level	M	SD
Enjoyment	Low Achieving	31.53	5.17
	Average Achieving	30.79	5.42
	High Achieving	32.33	5.14
Effort	Low Achieving	26.80	3.73
	Average Achieving	27.43	. 3.35
	High Achieving	29.50	4.85

Note. M = Mean; SD = Standard Deviation.

Research Question 3: "*Are there statistically significant differences in Effort score after a peer assessment activity between students at low-, average-, and high-achieving levels in a translation class?*"

A one-way ANOVA was conducted to determine if the self-reported Effort score was different for different levels: low achieving (n = 15), average achieving (n = 14), and high achieving (n = 12). Assumption tests showed that there were three outliers, as assessed by boxplot. The researchers decided to include the outliers in the analysis, as the ANOVA test was run twice with and without the outliers and both tests yielded the same results. Data was normally distributed for each group, as assessed by Shapiro-Wilk test (p > .05); and Levene's test of homogeneity of variances (p = .608) indicated that there was homogeneity of variances. Data is presented as mean ± standard deviation. As Table 3 shows, the Effort score increased from low achieving (26.80 ± 3.73) to average achieving (27.43 ± 3.35), to high achieving (29.50 ± 4.85), in that order, but the difference between these achievement levels was not statistically significant, F(2, 38) = 1.638, p = .208.

4. Discussion

Data analysis revealed that peer assessment had a positive effect on the performance of all students regardless of their achievement levels, as all students' final translation scores improved from their initial scores after peer review. Among them, the performance of students at the low-achieving level improved the most, followed by students at the average-achieving level, and then students at the high-achieving level. Data also indicated that the score change between the low-achieving and high-achieving groups, and between the average-achieving and high-achieving groups was significant. However, although both Enjoyment and Effort scores generated by the high-achieving group were higher in

numerical value than those from the low- and average-achieving groups, comparisons of both scores between the three levels showed no significant difference.

The findings of this study support the previous peer assessment research (Davies, 2000; Li & Gao, 2016) in that peer assessment may have unequal influence on student learning. The current study examined the relationship between peer assessment and student achievement levels from a different angle by comparing the degree of improvement between three student achievement levels: low achieving, average achieving, and high achieving. While all students, regardless of their achievement levels, improved their projects more or less after peer assessment, the comparisons between students' first-round and second-round submitted projects confirmed that the low-achieving students had the biggest improvement, followed by average-achieving students and then high-achieving students.

Interestingly, although the leveled effect of peer assessment on students' learning was supported by the statistical findings of this study, the comparison of mean scores of students' Enjoyment and Effort ratings did not show a significant difference between groups. These findings (significant difference on the change scores between groups and non-significant difference on Enjoyment and Effort scores between groups) seem conflicting but actually are not surprising. First, all three groups – low, average and high achieving – improved their performance on their final project submissions after peer assessment. Even though the degree of improvement as represented by the change score (between the initial and final project submissions) for the high-achieving group was not as high as that of the low-achieving and average-achieving groups, a further look at the high-achieving group data indicated a significant difference between its first- and second-round project submissions ($t11 = 9.100$, $p < 0.001$). In other words, students in the high-achieving group significantly improved their translation projects after participating in the peer assessment activity. On average, the second-round submissions were assessed 1.17 points higher than their initial submissions (95% CI [.89, 1.45]). This finding suggests a possible explanation for why the ratings of Enjoyment and Effort statements by the high-achieving students were similar to those of the other two groups. Since all three groups performed significantly better on their projects after peer assessment, it is not surprising that their intrinsic motivation rating (as represented by the Enjoyment score) showed no significant difference. The results also suggested that all students, regardless of their achievement levels, put forth comparable effort (as represented by the Effort score) into completing the peer assessment activity. It would be interesting for future studies to analyze if students demonstrate different patterns of participation and interaction across different achievement levels in a peer assessment activity.

5. Conclusion

This study examined how peer assessment may impact learning of students at different achievement levels in translation instruction. The findings of the study are in line with the results of the previous study on peer assessment (Li & Gao, 2016) and presented three relevant facts:

1) The peer assessment activity used in this study was effective in enhancing students' performance on an English translation project, regardless of students' achievement levels.
2) The peer assessment activity had unequal impact on learning of low achievers, average achievers and high achievers.
3) Comparisons of students' first-round project assessment (before peer assessment) and second-round project assessment (after peer assessment) showed that low achievers had the greatest degree of improvement, followed by average and then high achievers.

The significance of the study lies in the fact that this is an innovative study that investigated the impact of peer assessment on students at various achievement levels in translation instruction. Although the potentials of peer assessment are widely studied and well documented, it is still not fully understood what makes effective peer assessment (Li & Grion, 2019; Van Zundert et al., 2010). This paper is the second in a series on the "how peer assessment works" inquiries. The initial paper (Li & Gao, 2016) discovered an interaction between peer assessment and student achievement levels and suggested that low achievers may have the biggest learning gain from peer assessment, while high achievers have the least. This paper was specifically designed

1) to address one possible limitation in the initial paper, ceiling effects, and
2) to examine the impact of peer assessment on students' performance from a different angle by comparing the degree of performance improvement between the three achievement groups: low, average, and high.

The findings of this study confirmed that peer assessment had unequal impact on students at various achievement levels. What is more, the current papers indicated that high achievers also had significant learning gain from peer assessment, even though their learning gain may not be as much as that of the low and average achievers.

The finding of peer assessment significantly improving the learning of high achievers in this study seems contradictory to the finding of our previous study (Li & Gao, 2016) that suggested peer assessment benefits low or average achievers but not necessarily high achievers. However, the seemingly conflicting findings of the two studies may be explained, to some extent, by the ceiling effect theory. As discussed in the Literature Review section, the researchers (Li & Gao, 2016) speculated that "… *high achievers' scores were close to the maximum score on the lesson plan project, which may have created a ceiling effect and may have decreased the likelihood that the rubric had accurately measured learning gains of high achievers*." In other words, the researchers (2016) suspected that the lesson plan assignment was insufficiently difficult to measure high achievers' true knowledge or ability, as most of them made it close to the maximum score in their first submissions. The speculation of a ceiling effect existing in the previous article (2016) seemed to be confirmed by the findings of this study. An English translation project was purposefully chosen as the measure in this study, as the researchers believed that the project was at an appropriate difficulty level and it would be unlikely for most students to achieve very high scores in their initial drafts before peer assessment. It turned out to be an effective measure that lessened the ceiling effect and more accurately reflected the achievement of learners including high achievers. These two studies show that student achievement level is an important factor to consider in peer review activities. This conclusion opens up potential for researchers and educators to experiment with different ways to group students based on their achievement levels. For example, the instructor may consider intentionally grouping students at different achieving levels in the same group.

The findings of this study have important practical implications for educators and researchers who are interested in peer assessment in translation instruction or other fields. This study indicated that peer assessment is an appropriate instructional approach to benefit students at all achievement levels in the translation field. However, assessment criteria of translation assignments that are used to measure student learning in peer assessment should have appropriate difficulty levels that can accurately gauge student performance. If assessment tools are not sufficiently sensitive or reliable for distinguishing a difference in quality of translation work, students' immediate learning gains may not readily manifest, even though they may exist. While the details of the translation task are specific to language-learn-

ing students, the general principle of selecting activities with suitable difficulty levels to appropriately measure student performance applies across disciplines.

Given the cultural context of Chinese students, it's worth considering how cultural norms around giving and receiving feedback might influence their peer assessment process. For example, in some Asian cultures, young people endorse interpersonal harmony, hierarchical relationships and traditional conservatism (Zhang, Lin, Nonaka, & Beom, 2005). They may prefer providing and receiving indirect or subtle feedback to maintain harmony, cohesion or save face. This could potentially impact the nature and tone of the feedback provided by the students in peer assessment. Researchers and educators should consider these cultural nuances when interpreting the results of the current study. Future studies are warranted to replicate the study findings with subjects in other culture contexts.

In the past a few decades, technology has shaped and reshaped the education sector including the peer assessment field. In this study, Shimo Document was chosen as the collaboration platform to facilitate the peer assessment process. This productivity suite that is equipped with different features such as chat, documents, spreadsheets in a simple interface stood out as a robust solution to encourage interactions between students. In addition, Shimo's cloud-based nature facilitates both real-time and asynchronous collaborations and allows students to engage in the peer assessment process at their own time and pace. This anytime and anywhere feature can be particularly beneficial in accommodating students' diverse learning needs and various schedules.

While the study discloses some interesting findings, the researchers would like to acknowledge two possible limitations on the generalization of these findings. First, this study employed a specific group of EFL students who followed a specific peer assessment model to improve an English translation project at a Chinese university. The findings of the study may not be generalized to other peer assessment studies or other populations. The researchers call for future studies to determine if the study could be replicated and similar findings generated in other populations or with different peer assessment models. Second, this study used a fairly small sample that decreases statistical power and the flexibility of the effect size. Future studies are warranted to confirm the findings with bigger samples. Future studies should also employ a control group that does not follow the peer assessment procedure and should measure the enjoyment and effort scores before and after peer assessment. It would be interesting to see how these scores may differ between the treatment group and the control group, and before and after peer assessment activity. Designs that employ other research approaches, such as qualitative and mixed-methods, should also be considered in future studies so data triangulation can be used to help better understand student experiences when peer assessment is used in translation instruction.

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Inclusive science communication: Tools from the natural sounds

La comunicazione inclusiva della scienza: strumenti ispirati dai suoni della natura

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ABSTRACT Scientific popularization for people with sensory disabilities is today insufficient and lacking in specific methods as it uses contents rich in visual and abstract references, difficult to assimilate by those with perceptual or sensory deficiencies. This research aims to fill the gap through an exploratory case study, conducted with an inclusive and multisensory method. This method is based on the use of natural sounds to communicate complex concepts related to ecology and environmental vulnerability. It has a bottom-up approach, starting from a single theme to arrive at the definition of ecosystems and environmental emergencies. The results indicate that natural sounds contribute to students' learning by improving the ability to recognize and describe ecological and environmental issues. The proposed method was highly appreciated by the participants and exhibits excellent performance and great expandability to complex themes.

KEYWORDS Scientific Communication; Sensory Disabilities; Visually Impaired; Inclusiveness; Multi-Approach Method.

SOMMARIO La comunicazione scientifica, strumento efficace di conoscenza e sensibilità ambientale, è piuttosto inefficace per i disabili sensoriali che non hanno esperienza diretta della Natura. Essa, infatti, normalmente utilizza contenuti ricchi di riferimenti visivi e astratti, difficili da comprendere per chi ha carenze percettive o sensoriali. Nel caso studio qui presentiamo abbiamo sperimentato un metodo inclusivo e multisensoriale volto a promuovere la comprensione e l'assimilazione di informazioni ecologiche complesse legate all'ecologia e alla vulnerabilità dell'ambiente. Il metodo è di tipo game-based e utilizza suoni naturali con un approccio bottom-up, in cui partendo da un unico tema si arriva alla definizione di ecosistema e alle emergenze ambientali. I risultati ottenuti confermano che le persone ipovedenti e con disabilità sensoriali sono state perfettamente in grado di svolgere compiti di memoria passiva e si è rivelato efficace, avendo consentito di superare i limiti e la diffidenza basata sulla mancanza di esperienza diretta.

PAROLE CHIAVE Comunicazione Scientifica; Disabilità Sensoriali; Cecità; Inclusività; Metodo Multi-Approccio.

1. Introduction

Globally, 1.1 billion people have vision problems, including 43 million blind (of whom 55% are female) and 295 million visually impaired. For the coming decades, the forecasts are not favorable: both the number of blind and visually impaired is expected to increase (Bourne et al., 2021).

In previous research, blind people were asked what scientific research might do for them. Among the different answers, the need for specific training methodologies was highlighted (Duckett & Pratt, 2001). Unfortunately, scientific dissemination still generally relies on visual imagery and abstract references, which is only rarely adapted to the blind (Jones et al., 2006; Beck-Winchatz & Riccobono 2008).

To be effective, scientific dissemination must be as clear and inclusive as possible, clearly explaining complex and often inaccessible concepts such as those that are not tangible (Bickford et al., 2012). Synthetic information and the use of technology are the main factors that characterize modern scientific dissemination. These tools have benefitted a great development in recent years, becoming an important means for individual and collective enrichment. However, the development of scientific communication tools is still neglecting the needs of blind people and even today tools rich in visual and abstract references are re-proposed, which are difficult to be assimilated by those who have perceptual or sensory deficits (Fraser & Maguvhe, 2008; Papadopoulos et al., 2018; Suimuek et al., 2010). Especially in the study of biology, blind students are excluded from participating in experiments or field activities (Anđić et al., 2019).

In this paper, a proposal is made as to how to adapt complex environmental issues (such as loss of biodiversity, pollution, and changes in agricultural practices) to the needs of the blind people, based on their sensory perceptions. Social practices, such as emotional experience, have been applied in the form of game, that increases well-being and positive psychology, as it has been highlighted by positive testing in science teaching (Businaro, Pons, & Albanese, 2015). To do this, we used tools based on natural sounds, the theme of bird song and in particular the vocal mimicry of bird song species. The method we propose stems from Community-Based Participatory Research (CBPR) methodology (Baron et al., 2009; Wallerstein & Duran, 2010) which involves specialists in different disciplines and target groups.

2. Theoretical background

Efforts to make science dissemination tools inclusive are still sparse (Papadopoulos, Barouti, & Koustriava, 2018; Setti, Cuturi, Cocchi, & Gori, 2018). Most research has suggested designing web pages and web accessibility, but very few experimental studies have been conducted (Suimuek, Altun, & Ateu, 2010). Methods for spreading the key scientific concepts are very much related to visual elements, without any stimulation of the other bodily senses, resulting in poor or absent content inclusion (Ahmetovic et al., 2010), so that disabled people manage to have a very low level of scientific background (Fraser & Maguvhe, 2008). Consequently, people with sensory disabilities (especially those with visual impairment) face problems in the perception of scientific information.

This could be overcome by developing new strategies (Flórez-Aristizábal et al., 2018) to implement science dissemination, drawing inspiration from disciplines such as art, music, or dance (Lesen, Rogan, & Blum, 2016), as well as artistic forms with high communicative value that use all bodily senses in a compensatory way. However, very few examples in this direction are found in literature. Recently, Anđić and colleagues. (2022) show that touch experience using 3D modelling and printing

help blind students to distinguish plant and animal cell parts, visualize the cell and its parts, as well increasing student spatial abilities.

Besides touch, listening can also be an innovative means of scientific dissemination. Listening to natural sounds is an important instrument for scientific inquiry. When ornithologists carry out censuses, they use much more hearing than sight to recognize different species, especially in particular environments.

Each environment is characterized not only by different physical and vegetation conformation, but also by a specific, sound landscape that overlaps and increases its total complexity. The soundscape is therefore an element that helps to identify a place and increases or decreases its quality. For example, we know that very noisy places produce changes in the behavior of many animals, including humans, and thus are often avoided by them, in favor of places with a more comfortable sound frequency. When the landscape sound represents just an immersive place, in which animals live and to which they undergo, the soundscape holds a passive function. But it also holds an active function in which the landscape sound is considered an important means of communication (Pijanowski et al., 2011). Birds use sound manifestations extensively as a means of communication, even having a specific organ, the syringes, and a modified larynx, which allows them to emit a great variety of songs, calls, and vocalizations, in respect to other animals.

Singing is of great importance for birds as it is the instrument for contact, courtship, and defence. The timbre is often the peculiar feature of species, thus representing a species-specific identification element.

To the best of our knowledge, there is no research that explores the contribution of natural sounds to science dissemination, which was the reason for choosing an exploratory case study for our research.

3. Context

The research was proposed as part of an "inclusive communication" experimentation path developed by the National Research Council of Italy (CNR) in collaboration with the "Florio Salamone" Institute of the Blind of Palermo. The CNR researchers were specialized in Ecology and Biodiversity and had a great knowledge of science dissemination, developed over the years with many projects targeted to schools of all levels. Specialists from the Institute of the Blind were involved in the design of the laboratories, including the director, sociologists, psychologists, and social workers. The users of the laboratory were subjects who usually attend the institute for recreational and educational activities and who have already developed a relationship of trust with the staff.

The group of specialists devised a playful educational path aimed at increasing knowledge of the natural environment and the related management aspects; these themes had never been proposed in the previous activities of the Institute. After getting to know and become familiar with the blind or visually impaired students of the Institute, their degree of knowledge of natural systems and their appreciation and interest in natural themes was verified through discussions and debates. Following these exchanges of views, it was decided to further explore the theme of birds and their protection as the aerial environment and the world of birds seemed to be the least known. Most of the blind and visually impaired had also shown distrust and circumspection towards these animals; also a blind woman said she was afraid of birds, calling them dangerous and unreliable. To increase knowledge and try to increase familiarization, a cognitive path was then formulated.

Participants consisted of three groups of users with different sensory characteristics (Table 1). The first group consisted of 23 visually impaired people, the second group of 20 blind but blindfolded peo-

ple, the third group consisted of 20 sensory disabled people, with mild to moderate mental disorders, cognitive impairment and some with developmental delays. 50% of this sample was totally blind, 25% visually impaired, the remaining 25% normal sighted. The whole cognitive path was formulated in a series of meetings in which the biology and ecology of birds were discussed through meetings, games and manipulative activities, such as building nests, manipulating eggs and feathers, building-colored wings, the combination between the shape of the beak and food, etc., activities that allow an increase in confidence with the theme. The last of these activities was the game on bird songs and their recognition, which will be explained in detail below.

We informed users that their responses would be recorded as scientific data. During the activities, we followed the ethical principles of the Declaration of Helsinki and collected information about the participants after obtaining their written consent or that of their parents/legal guardians.

Table 1. Composition of the groups of participants in the laboratory.

Characteristic of the Group	Females	Males	Age	Vision skills
Group 1: Blind or visually impaired	12	11	19-64	50% Blind 50% Low Vision
Group 2: Normally sighted	10	10	18-20	Normally sighted but blindfolded
Group 3: Down and Williams-Beuren Syndromes	2	18	18-30	50% Blind 25% Low Vision 25% Blind

4. Methods

To understand how natural sounds influence and contribute to knowledge and learning processes in inclusive classrooms, we conducted an exploratory case study. Cohen, Manion and Morrison (2000) and Yin (2018) recommend that an exploratory case study should be used when there is not sufficient prior research. Mills, Durepos and Wiebe (2009) also suggest that the exploratory case study should specify procedures for the collection and processing of data, so that they can be used for future research. Therefore, in the following we describe in detail all the steps in our case study.

4.1. Structure of the proposed activities

We proposed a playful-practical laboratory, envisaging a kinaesthetic part to allow a sensory disabled public, with varying degrees of blindness, to reach zoological and scientific contents and therefore reconnect to more general problems, such as the numerous environmental emergencies for this decade.

The activities started with two familiarization meetings where the group of specialists and that of the users introduced themselves, had a snack together and discussed environmental issues, exchanging information and curiosities to understand how much interest there was on these topics and whether such an experimental activity with birds could be interesting for them. After assessing the topic positively, we entered the heart of the activities.

The third meeting focused on birds and their biology to introduce the main concepts on the ecology of these species. A lecture was given, lasting half an hour; then, users were proposed to observe and manipulate small fake birds, made with real duvets / bird feathers. This activity was aimed to decrease fears that these animals aroused in some subjects. Subsequently, we proposed the use of bird songs,

and all together decided the methods of development, identifying the objectives. All users chose to participate in the laboratory and chose their partner in the couple's activity.

4.2. Contents and objectives

Targeting an audience affected by various degrees of visual impairment (see Table 1), we needed a bird model species that would simultaneously represent a stimulating attraction at a multi-sensorial level, and that would allow us to convey environmental concepts. So, we chose the Calandra lark Melanocorypha calandra, a medium-size Passeriformes, from the family of Alaudidae and with a mainly Mediterranean-Turanic distribution (Mediterranean countries, Central Asia). Mainly steppe-like songbird, it has a strong and very varied song. Males sing in flight or from raised perches throughout the entire breeding season. The peculiarity of this species is the mimicry song: they include several insertions, within its own song, of short phrases or verses of other drylands bird songs, thus enriching their own vocal repertoire (Dalziell et al., 2014). In his courtship, the better he does it, the higher the probability of being chosen by a female.

Taking advantage of this imitative behaviour, we wanted to understand if users with sensory disabilities a different tendency had to recognize imitations, compared to able-bodied subjects and if this listening-based methodology was able to convey complex information and help memorize them.

More in general, we wanted to verify whether – thanks to the proposed set of activities - it was possible for our users to store a large amount of completely unknown information and stimulate curiosity and memorization of these concepts.

This laboratory also allowed us to verify whether the methodology was suitable for blind people and people with syndromes, in comparison to people with normal skills.

4.3. Materials and technologies

The tactile part of the laboratory consisted of the manipulation of 6 statuettes of the species whose songs were those of the species imitated in the audio part. The 6 species selected were: Little owl (*Athene noctua*), Eurasian goldfinch (*Carduelis carduelis*), Linnet (*Carduelis cannabina*), House sparrow (*Passer domesticus*), Crested lark (*Galerida cristata*) and Yellow Motacilla (*Motacilla flava*) (Table 2). The remodels/copies of the species were faithful done in terms of colour and size, they were made using brown DAS and then painted with tempera colors. The natural colors of the species were emphasized to facilitate visualization for visually impaired people, breaking down their perceptual barriers.

The audio-video part of the laboratory consisted of the audio track of the 6 species mentioned, and two videos that reproduce their own songs and the imitative songs of the Calandra Lark males. The audiovisual part of the experiment was conducted with a simple laptop and two pairs of noise isolating headphones. The songs were selected after having seen dozens of them with the male singers of Calandra uploaded to free web platforms (YouTube, Vimeo, Veoh). The selection criteria were the following: imitations of at least 3 of the 6 selected species, good acoustics, subject in the foreground. The audio track was extracted from the selected tracks using the free downloadable program Audacity[1], to scientifically attest the imitation of the bird's call picked up by the human ear; the traces were visualized on the spectrograms (Figure 1).

[1] https://www.audacityteam.org

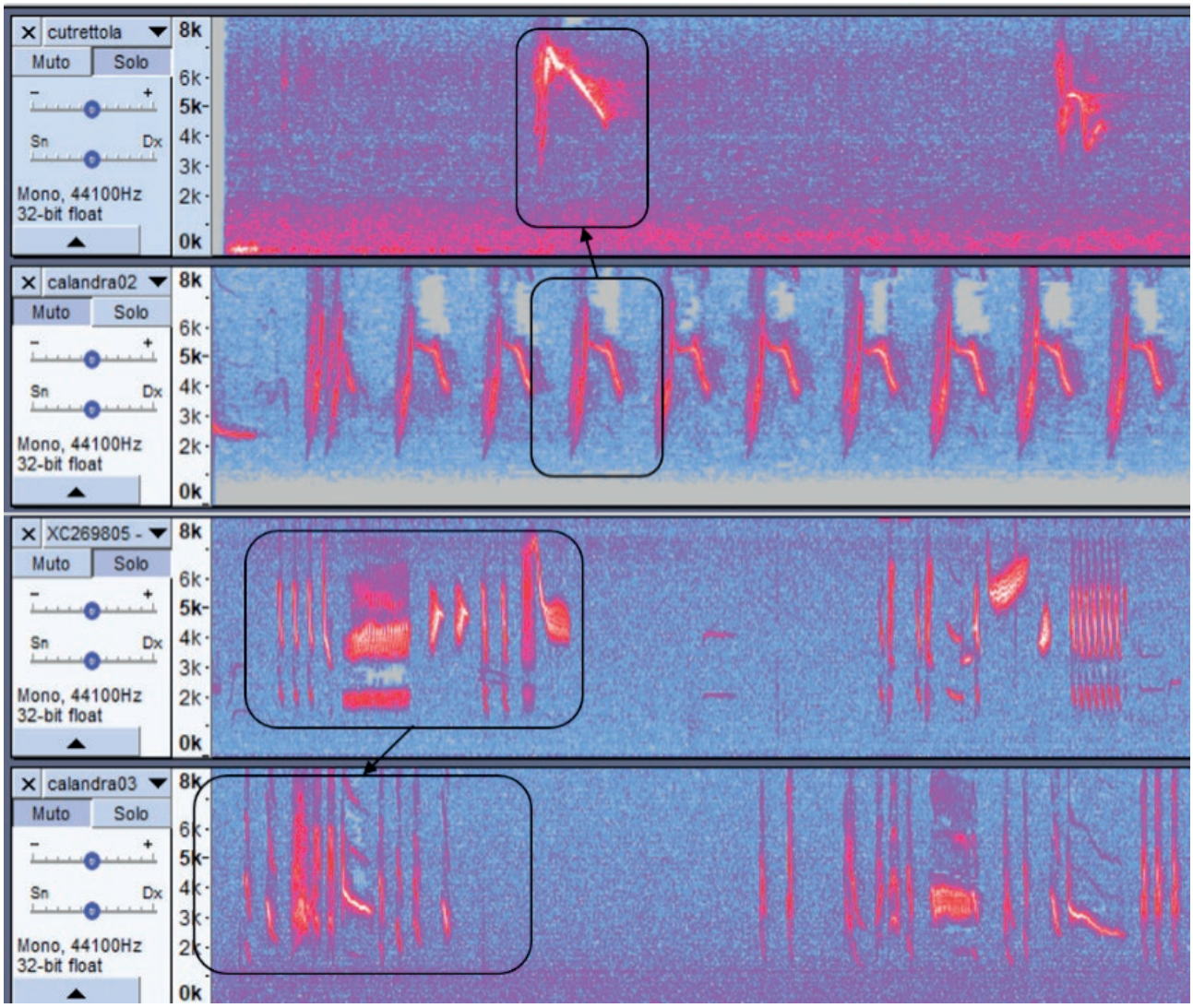

Figure 1. Spectrograms of vocal mimicry of Calandra lark bird (2nd and 4th stripes) compared to imitated species: Yellow wagtail (1st stripe) and Linnet (3rd).

4.4. Data collection

The audio testing was carried out in two different phases. The subjects, in pairs, were seated on two comfortable chairs and the audio device was positioned at 50 cm, with an imaginary line between the two users. Each user was equipped with insulating headphones to listen to the audio tracks without external distractions. In the first phase, the audio track of all the imitated bird species was heard twice, accompanied by an image of each species, a brief oral description and some characteristics of their singing. In the meanwhile, the user was free to look at and explore with both hands the scale statuette of the imitated species, to become familiar with the species. Then, we played a "audio test" reproducing the proper sing of a male of Calandra Lark, to allow the user to get used to his singing when he is not making imitations. The spectral density of the Calandra Lark's song was compared with the spectral density of other birds' songs, to access the actual mimicry of the bird song in the audio track.

Finally, we reproduced the imitator bird tracks, in which it alternates its song with that of other birds. Both songs lasted about a minute and after that they were able to respond to what they had heard. At the end of the session, we asked users how many bird species they recognized by pointing to the name, or by touching the species they recognized with a pointer.

In the six months following the activities, we organized a visit to CNR with the blind participants. During the visit we were able to ascertain that the group kept the memory of the birds, their ecological importance and the division into species of the bird object of the game. After several months, the group asked us again to organize new sessions and speaking with the psychologist of the Institute, he showed that he remembered the contents of our workshops which he considered fun and interesting experiences. For us, this is certainly an indication of appreciation of this type of experience and strengthens our belief in its usefulness.

5. Results

User responses were recorded and subsequently statistically weighted in a score system. From the users' answers, the number of species imitated in the video is taken on the total number of species indicated by them. A statistical correction is then applied: given a certain number of detections, it represents the probability (between 0 and 1) that user must guess the 4 species by pure chance. It is therefore maximum when the user mentions all 6 potentially imitating species, 0 if the user indicates less than 4 species. The use of this index is aimed at considering that the user indicating a high number of imitated species is more likely to score higher by pure chance. In fact, if all 6 species are named, undoubtedly the 4 presents in the video are guessed. Users who cited many species receive a greater penalty than those who cited a few. The final score is calculated as the number of correct answers, subtracting the penalty and statistic correction. In order not to report negative values, the final ranking is normalized to 0. Graphics and statistical analysis were performed with R, spectrogram is performed with Audacity.exe.

All three groups scored on average above 0 (Figure 2), with a median value of 3 for sensory disabled and 5 for normally sighted and blindfolded. We noted differences between all three groups, if we consider the values of statistical averages: 3.10 ± 1.79 for sensorial disabled (max score 6, min score 0), 4.42 ± 1.66 (max score 6.67, min score 1) for normally sighted and 4.97 ± 1.22 for blindfolded (max score 6.67, min score 3). The percentage of wrong answers was 41% for sensory disabled, 30% for normally sighted and 25% for blindfolded.

In general, considering the totality of the right and wrong answers given during the sessions, it was noticed that normally sighted people tend to choose the more colored and flashy species, while this preference is not evident in the groups of sensory disabled and blindfolded (see Table 2). Furthermore, sensory disabled people tend to use species with names known and used in every-day language, rather than the species whose names are not common (see Table 2). This did not occur for the other two groups. However, this tendency has no statistical significance (T test gives all result with $p > 0.05$), probably due to the small size of the sample. The implementation of correlation analysis has not shown statistically significant correlation between the users ages and the experiment performances.

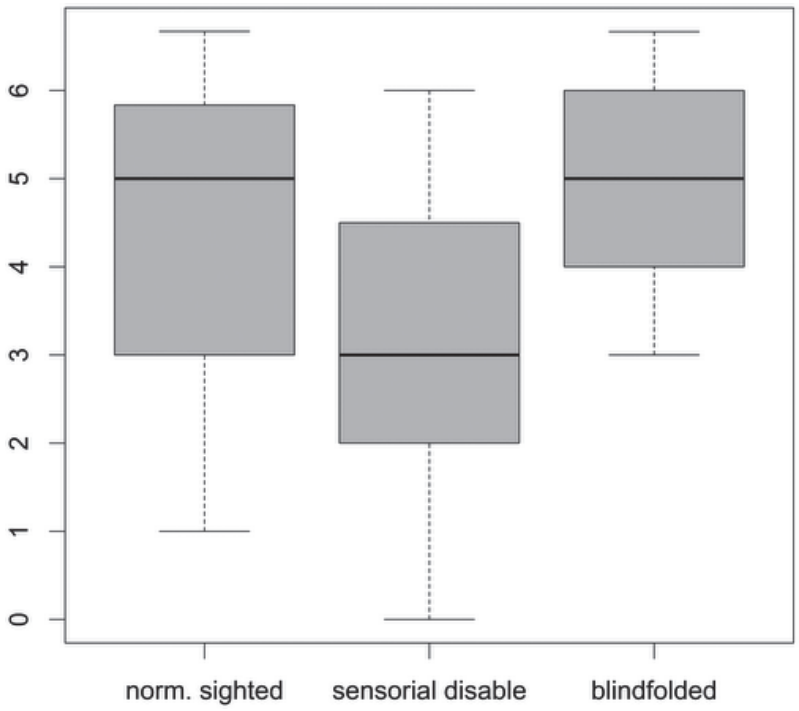

Figure 2. Boxplots of test results. In y axes the test score.

Table 2. Variables of birdsong taken into consideration: appearance of the plumage and use of the specific name even among those not in the ornithological field.

Species	Colours		Name	
	Bright	Fawn	Usual	Unusual
Crested Lark		X		X
EurasianGoldfinch	X		X	
House sparrow		X	X	
Linnet	X			X
Little owl		X	X	
Yellow wagtail	X			X

6. Discussion

In the present study, our first aim was to test a method to make available contents that would have been otherwise difficult to access for sensorial disabled people. We wanted to test whether a multisensory approach could improve performance in the assimilation of scientific contents and whether this effect would be of help for blind people.

In fact, our method was based on:

1) a tactile approach given by the physic representations of the imitated species,
2) an acoustic approach to memorize/recall the different songs by an imitating species and identify them as distinct sequence in the audio file, and

3) a visual approach (for normally sighted and visually impaired people) by brightening colors in representations of imitated species.

Positive results obtained by all groups confirm that, despite the lack of vision, sensorial disabled people can perform passive memory tasks, as long as they are asked to remember sequences of unspatialized sounds, associated to the active manipulation of objects.

A reason for the lower performance of sensory disabled people could lay in the fact that blind and visually impaired subjects are often reluctant to face new situations, especially those they are not able to fully control. This was especially evident in our case for some users who present some aspects of the autistic spectrum. We noticed that the active manipulation, the explanatory meetings and our continuous descriptions, even during the test, seemed to have mitigated the initial attitude of diffidence shown by the disabled people towards the birds (see introduction), which instead seemed amused and more confident. With the introduction of identity and meaning for the birdsongs, related to a physical animal, sighted individuals were able to construct, and subsequently use, a functional image of the scene that helped them to locate and remember the sounds. The lack of vision leads to specific difficulties when congenitally blind individuals must create interactive images that involve several items at the same time. Simultaneous perception and manipulation of more than one object is typical of vision, while haptic and auditory perception, widely used by visually impaired individuals, mostly rely on sequential processing. Vision facilitates simultaneous processing at high cognitive level and thus the absence of vision might reduce the ability of visually impaired people to properly process large amounts of information at the same time (Rios-Chelen et al., 2012).

Having therefore the foresight to divide the stimuli in such a way as to focus on one species at a time, so as to assimilate the song well, the shape of the bird's bodies and the characteristics of each individual species, allowed the sensory disabled to be able to recognize an identifying element (the song of the species) within a heterogeneous pattern faced for the first time as a stimulus (the song of the Calandra lark and its imitations). Preliminarily, we found during the test that the sensory disabled had positively independently recognized some of the songs of the six species examined, especially those related also to urban contexts (Linnet, Eurasian Goldfinch, House sparrow) and previously heard, but not associated with any species, for lack of prior knowledge. The group of disabled people also showed strong positive feedback in the science dissemination lessons that preceded and followed the experiment: the majority of those who positively recalled the experience and could argue the biology and the ethological peculiarities of the Calandra Lark Bird, remembering also which species they had heard singing. This method allowed them to learn complex scientific issues quickly, using a bottom-up approach that from single elements (the birds of agroecosystems) rose towards the ornithic communities, the definition of ecosystem and the environmental emergencies of agroecosystems. Our experiment allowed us to study how the exploration of an inclusive method, using a multi-sense approach, impacts on storing and recalling of scientific information. Although both sighted and blind individuals show similar audio memory skills, the latter have only a partial access to abstract scientific concepts processing of multiple stimuli, even if presented through a non-visual modality (Setti et al., 2018). This result is also important in the context of developing new solutions and technologies to enhance environmental representations in visually impaired individuals. It is interesting to note how the blindfolded group, despite similar results to the normally sighted (even higher, considering the statistical average) acts similarly to the group of blind and visually impaired people. Given the impossibility of storing species by visual memory, this group did not show a selective preference for the most colorful and showy species, which instead had a greater appeal to sighted people. We also think that

the high performances of this group, bigger than the other two, are due to the impossibility of seeing the video, where the moving image of the singing Calandra Lark Bird can provide a possible distraction, influencing the concentration during the test and the detection of the imitated songs.

7. Conclusions

We have provided vocal, visual, and auditory codifications to facilitate the mental representation of a concept, starting from a single stimulus (the song) to then move on to a series of stimuli in series (the imitative song of the Calandra Lark Bird) and introducing an intangible argument through environmental interpretation (biodiversity loss, pollution, and changes in agricultural practices) through other sensory modalities. This scientific result suggests that the storage of spatial contents works by storing information in a pictorial and descriptive manner (Dalziell et al., 2014) and such are the stimuli we provided to increase the inclusiveness of our scientific contents: representations through objects with vocal and acoustic descriptions of concepts to memorize. Creating inclusive methods means offering everyone the opportunity to reflect on issues of social and environmental interest, which have important repercussions on daily life and the future of humanity. With this vision, we believe inclusive science dissemination activities should evolve rapidly becoming more effective, creative, and inclusive. Although the perception of this phenomenon seems to be growing, science communication must have a common goal: to involve everyone and provide adequate tools for inclusive communication. In this work we wanted to experiment with a small useful tool to bring those with sensory and perceptive difficulties closer to nature, its species and the issues of environmental sustainability in the hope that tools such as the one we have experienced can be increasingly widespread in scientific dissemination.

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Critical digital literacy and active citizenship at school: The experience of the Scientix Ambassadors

Digital literacy, senso critico e cittadinanza attiva a scuola: l'esperienza degli Ambasciatori Scientix

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ABSTRACT Quality education represents one of the leading goals among the United Nations sustainable goals and its centrality is internationally recognized. The paper, after reviewing how to reach quality education and which competencies students should reach, presents the Scientix project. With a participatory action research and peer-led experiential learning approach, a number of experiences are shared as a proof of concept about educational intervention coupling research and practices. The experiences cover all school levels and aspects spanning Information Literacies related to online inquiry process and source validation and verification; Data Literacy and its importance for active and critical participation in society; Digital Citizenship and sustainable use of technologies and digital civic engagement and technology use related to Computational Thinking and coding. The work lays the basis for the assessment of key factors in learning resource design and key educational practices with the greatest positive impact on the students' learning path.

KEYWORDS Competencies; Coding; Computational Thinking; Active Digital Citizenship.

SOMMARIO L'istruzione di qualità rappresenta uno dei traguardi principali tra gli obiettivi sostenibili delle Nazioni Unite e la sua centralità è riconosciuta a livello internazionale. Il lavoro, dopo aver esaminato come raggiungere un'istruzione di qualità e quali competenze gli studenti dovrebbero raggiungere, presenta il progetto Scientix. Con una ricerca-azione partecipativa e un approccio di apprendimento esperienziale guidato da pari, l'articolo presenta una serie di esperienze come prova di fattibilità relativa ad interventi educativi che coniugano ricerca e pratiche didattiche. Le esperienze coprono tutti i livelli scolastici e aspetti che spaziano dalle alfabetizzazioni informatiche relative al processo di indagine online e alla convalida e verifica delle

fonti alla Data Literacy e la sua importanza per una partecipazione attiva e critica nella società; dalla cittadinanza digitale e l'uso sostenibile delle tecnologie per un impegno civico digitale all'uso della tecnologia con riferimento al pensiero computazionale e alla codifica. Il lavoro pone le basi per la valutazione dei fattori chiave nella progettazione delle risorse di apprendimento e delle pratiche educative con il maggiore potenziale per un impatto significativo sul percorso di apprendimento degli studenti.

PAROLE CHIAVE Competenze; Coding; Pensiero Computazionale; Cittadinanza Attiva Digitale.

1. Introduction

As suggested by (UNESCO, 2017), quality education is one of the United Nations' sustainable goals and is considered fundamental for reaching all sustainable development goals.

In the attempt to reach quality education, different international frameworks have been proposed related to the competencies students should possess.

Among these frameworks and recommendations, we recall the European Council recommendation for key competencies (Council of the European Union, 2018)[1] that include: Mathematical, science technology, and engineering; Literacy; Digital; Personal, social, and learning to learn; Citizenship; Entrepreneurship; Cultural awareness and expression; Multilingual.

Another global competencies framework comes from the Programme for International Student Assessment framework by the Organization for Economic Co-operation and Development (OECD, 2019). According to the OECD, global competencies should be acquired within a life-long learning journey that is shaped by education. Among the most important competencies, it is possible to recall:

- how to use media platforms effectively and responsibly;
- how to support the Sustainable Development Goals;
- how to live harmoniously in multicultural communities.

The importance of digital technologies for learners is also stated in the European Framework for the Digital Competence of Educators (DigCompEdu) (Redecker, 2017) which indicates that educators should equip their learners with digital competencies related to information and media literacy; communication; content creation; responsible use of digital technologies, and problem solving.

In other frameworks, similar competencies are extended, likewise the DigiComp set of frameworks, to all citizens (Gousetti, 2021; Vuorikari et al., 2022), firms, enterprises and to the whole of society.

Research studies, such as (Clear et al., 2020), have demonstrated how the transition from learning-outcomes-based practices to competency-based practices can be approached.

This work, leveraging on previous experience in research and teaching practice collaborations (Panconesi & Guida, 2017; Maiorana et al., 2020a; Niewint, 2022) aims to share a number of experiences designed and carried out by teachers belonging to a project called "Scientix" aimed at developing some of the above mentioned learners' competencies.

The paper is structured as follows. Section 2 provides background information related to the Scientix project. Section 3 briefly describes the methodology, Section 4 presents the in the field experiences, Section 5 presents a discussion and proposes a roadmap, and finally, Section 6 draws conclusions and highlights further work.

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018H0604(01)&from=EN

2. The Scientix project and the Ambassadors' Community of Practice

Scientix is a European project, whose aim is to promote and support a Europe-wide collaboration among STEM (science, technology, engineering, and math) teachers, education researchers, policymakers, and other STEM education professionals[2].

The project's actions are supported by a European-wide network of "teacher ambassadors", trained and assessed yearly, whose work is "essential for expanding and consolidating a community whose core values reside in sharing good classroom practice, especially in the area of STEM, and making sure that students are equipped with the skills needed to become successful adults".

For the purpose of accomplishing these ambitious goals, the Scientix community is supported by a set of cutting-edge tools, including:

- the Scientix Observatory, a repository of articles, focused on science education;
- the Resource repository, a collection of teaching materials, reports, training courses, and learning materials. It is important to note that all the resources are open access. Moreover, the Scientix project offers a free translation and localization service to all cultures and languages of the European Union, offering inclusive access to quality education material to learners facing language barriers;
- the project Repository, collecting research and teaching information of all the Science Technology Engineering, and Mathematics (STEM) projects funded by the European Union.

3. Methodology

To collect the experiences that are presented in this contribution, one of the authors launched a call within the Scientix ambassadors' community. As a result, a number of them volunteered to engage in a research-based reporting activity to improve their research and teaching practice and to nurture the seed of a self-directed small community of research engaged teachers.

Building on the experience reported in (Maiorana et al., 2022; Maiorana et al., 2020a; Maiorana, 2020b), the process followed the following steps:

1) Call for experiences: topics, and grade band
2) Asynchronous online negotiations on topics and decisions on topics
3) Discussion on a reporting template according to research guidelines such as (McGill et al., 2018)
4) Online sharing of the experience reports which were peer-reviewed
5) Crafting a list of references for reflections and discussions
6) Drafting of the discussion and conclusion with peer review.

Considerable importance was attributed to point 6, encompassing an activity of collaboration, cooperation, and revision among teachers. We know from research that reviewing someone else's work can be a powerful learning mechanism. Furthermore, the exchange of good practices and the comparison of pedagogical ideas with peer colleagues is an effective way to evaluate and develop one's practice and also recognize the different points of view. This has been demonstrated at all levels, from research to daily teaching practice especially in high school and tertiary education (Finkenstaedt-Quinn et al., 2021; Bangert-Drowns et al., 2004; McGill, 2018; Avison, 1999; Swennen, 2020).

Thanks to this process, several experience reports were collected.

This paper summarizes the didactic experiences of a representative sample of the Scientix commu-

[2] https://www.scientix.eu

nity of practice. The activities presented and the contents selected are fully intellectually justified on the condition that recognizes and conceives the existence of the interconnections of knowledge, skills, and competencies with solidarity (Morin, 2000).

4. Results: on the field experiences

In the following, we report some of the Scientix ambassadors' on-the-field experiences. In particular, the described activities cover the following areas:

- climate change;
- sustainability and digital civic engagement;
- hydroponic greenhouses.

4.1. Climate change and digital civic engagement

This experience was conducted during the Covid-19 pandemic in a primary school context for students aged from 8 to 10. It related to climate change and aimed to make the young students aware of the concrete actions they can perform in the context they live: family, school, and social activities with peers. The didactic intervention was designed with an interdisciplinary perspective embracing Italian, Geography, History, Science, Civic Education, Art and Technology. This type of problem-based learning is well suited for any subject area (science and humanities) and also in the social sector of education due to the emphasis produced on real-world problems and the human system. In summary, children were involved in solving problems with authentic experiences within their daily context. Table 1 summarizes the class schedule of the overall activity, which spanned through 8 weeks and included various steps/tasks.

Table 1. Class schedule of the climate activity.

Week	Steps/ Tasks	Resources and tools
1	Climate change issues and our actions to save the planet	Video, Eco-kit
2	The climate change: dictation	Dictation
3	Online inquiry process and reading comprehension, source validation and verification. Creative digital expression	Reflection questions. Electronic devices.
4	Express your view of the planet. Drawing	Paper and colors
5	A weekly data collection and weather report	Paper&pencil, wordprocessor
6	Celebration of World Meteorology Day. Interview grandfather on climate related proverbs. Write and drawing	Exercise book and colors. Tablet.
7	Reflections on activities for energy savings. Choose and motivate how and why we can avoid using electric machines	Exercise books and pencil
8	Celebration of the World Electric Saving Day. Energy and environment protection. How to collect and recycle waste	Interactive games

Week 1- Climate change issues and our actions to save the planet

Activity: Presentation of the topic by watching two previously selected cartoon videos and eco-kit.

The first tells of a child who dreams of experiencing a very hot winter and finds himself without water. The adults gather to make decisions on what to do.

The second tells how our daily behaviours can worsen or improve the conditions of our Earth.

Week 2 - The climate change: dictation

Activity: Dictation of an informative text entitled: "Climate Change". Reading and reflections on the written text.

Week 3. Online inquiry process and reading comprehension, source validation and verification. Creative digital expression

Resources and tools*:* Reflection questions; electronic devices.

Activity: Inquiry process. Reading and reflections on the written text.

Answer the stimulus questions and find information by cutting out images from newspapers or free drawings:

a) Global temperature is increasing. What are causes and effects?
b) What can we do? How and why?

Week 4. Express your view of the planet. Drawing

Resources and tools*:* Paper and colors.

Activity: Inquiry and reflections on questions. Feedback.

The students' reflections are written under their names.

Time for thoughts about drawing.

Topic: Draw in your exercise book how you see planet earth sustaining!

Week 5. A weekly data collection and weather report

Resources and tools*:* Paper & pencil, word processor

Activity: Observation of the weather in a week. Data collection of the climatic conditions every day at the same time and recording in a table.

Week 6. Celebration of World Meteorology Day. Interview grandfather on climate related proverbs. Write and draw Resources and tools*:* Exercise book and colors. Tablet.

Activity: March 23rd is World Meteorology Day! Interview grandfather on climate related proverbs. Write and draw.

"Ask your grandparents or parents for a proverb to remember the day dedicated to the weather. Then write it in your exercise book and draw a picture".

Week 7. Reflections on activities for energy savings. Choose and motivate how and why we can avoid using electric machines

Resources and tools*:* Exercise books and pencils.

Activity: Children are presented with drawings of some household appliances used in homes. Choose an appliance that you think you can stop using and explain why you can do without it. What does energy saving mean?

Week 8. Celebration of the World Electric Saving Day. Energy and environment protection. How to collect and recycle waste

Resources and tools*:* Interactive games.

Activity: Two young UNICEF volunteers discuss the topic of energy and environmental protection. The volunteers present some interactive games and invite the children to behave correctly to avoid waste.

4.2. Sustainability and digital civic engagement

Another interesting experience reported by the Scientix ambassadors came from a project called "Motion on schools" (MOS), which aims to promote good practices on the theme of environmental sustainability, by supporting the use of innovative practices to make students and staff real drivers of change by opting for sustainable mobility choices when they go to school. In Italy this was implemented with the "Pedibus" experience, which is about reaching school on foot in groups, to expand to the sharing of cars from a car-sharing perspective. Smartphones and WhatsApp® are essential for fast and instant messaging that allows participants to respond to last-minute unexpected events and to manage times and stops. Punctuality, courtesy, and mutual respect are essential elements of the itinerary sharing that must be planned and managed by the team. The first moment of the incoming day therefore becomes preparatory to the continuation of the activity at school and has enormous educational value, encouraging a shared seriousness of purpose in management because participants are no longer alone but in a group. The itinerary stops can become anchors of personal and historical memories in a story that accompanies the group while approaching the school and that can be taken up and deepened by the teacher, including in an outdoor space for an emotional closeness or bond to the neighbourhood or the city.

4.3. STEM and coding in hydroponic greenhouses

Another interesting experience came from an experimental project called "Serre idroponiche a scuola", promoted by INDIRE. In this project investigation and modelization are essential elements of the proposed approach, according to which students design an experiment using the scientific method, observe a phenomenon with its variables, collect data, and define a model of the studied phenomenon.

Following this approach, students of a high school in Follonica (Italy) built a hydroponic greenhouse. They started by designing a study about the growth of a plant and measured parameters for one month. Different groups of students measured different physical or chemical parameters. Afterward, using a program like Scratch, students in groups created the forecast model of their data. The resulting modelization showed future scenarios about plant growth, biomass production, or water requirements. Then they compared biological and virtual experiments. In STEAM education this "bifocal method" (Guasti et al., 2023) allows to improve thinking skills and creative skills. The inclusive effect of this work seems to be more impactful than other approaches because every student is involved in assessing their own work and their team's work. Previous studies underline that the bifocal method has also a positive effect on special needs students (Fuhrmanna et al., 2022).

In this experience, the teacher acted as a guide, giving feedback to the team during the work, and motivating every student to develop their skills. Different competencies coming from various STEAM disciplines were somehow required to carry out the activity, such as the scientific method of physics, knowledge of biology, coding in informatics to create forecast models, etc. Creativity was developed at each step of the activity because students wrote web diaries to show data and observations and communicate with each other (Salehi et al, 2013).

5. Discussion

All the reported experiences are characterized by innovations in content, pedagogies, and technologies, according to the TPCK framework (Archambault & Barnett, 2010).

The content innovation came from exposing students to real-life problems in all school grades. In line with the OECD "Recommendation of the Council on Creating Better Opportunities for Young People"[3], the above experiences can be considered examples of youth engagement with global challenges, such as climate change and digital technologies.

The innovation in pedagogies came from the Inquiry Based approach, which characterized all the activities and is typical of the Scientix community; this was coupled with a problem, project, and challenge-based approach. Moreover, creating a class climate of mutual care (Maiorana et al., 2022; Freire, 2002; Ko, 2021) was considered of paramount importance: even if it required a consistent amount of time and energy, it contributed to the development and promotion of social inclusion and youth well-being, both considered building blocks by the OECD recommendations. These pedagogies also improved the quality of communications at all levels, in line with the Manifesto of Non-Hostile Communication used in several contexts such as (Cristaldi, 2022; Giuliani, 2023), according to which developing a kind approach to conflict resolution is the best strategy to support young people's engagement in social action.

Finally, innovation in technologies came from the use of cutting-edge technological tools to support communication, collaboration, learning scenario design, and domain specific needs typical of the disciplines.

6. Conclusion and further work

This work, leveraging on authors' extensive practice as educators and researchers, proposes a set of experience reports rooted in research, nurtured through the Scientix ambassadors' community and involvement in several projects both inside the Scientix community and directly led by the ambassadors. The experience reports are related to several domains of the new critical digital literacies framework: technology use, data and information literacy, and digital citizenship. The age range of the students involved in the reported experiences covers the whole school path from primary to secondary schools.

As a further step, we plan to evaluate the use of the proposed interventions through

– a) student pre and post-tests;
– b) student self-assessment;
- c) end of activity student surveys.

We will collect qualitative and quantitative data and compare them with a control group when possible. This further study aims to distill best practices for designing, developing, and deploying learning activities to maximize the impact on students' progression through achieving critical digital literacy competencies.

[3] https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0474

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