Abstract

Creativity plays a central role in children's development and well-being, being considered a crucial skill to thrive in their personal and professional lives. Given its importance, researchers and educators highlighted the need to enhance creativity in individuals across the lifespan. However, it is crucial to understand how interventions and programs can promote creativity from an early age. The goal of this systematic review was to collect, summarize, and present evidence on research about nurturing creativity in children of elementary school age (5 − 13 years old), by systematically reviewing publications from 1950 − 2020, spanning 70 years of research. We additionally contributed to a classification system for characterizing creativity research by expanding on an existing coding scheme for creativity. This review resulted in the profiling of existing trainings that stimulate creativity in children. We discussed the results taking into account possible implications for practice and policy-making and future research directions in creativity research.

Keywords: Systematic review, creativity, intervention, program, children

Introduction

Creativity brings joy, wonder, excitement, efficiency, and pleasure into our lives (Baer, 2017; Kaufman, 2018). It relates to individual well-being, self-expression, and a sense of identity (Collard & Looney, 2014; Robinson, 2011). Indeed, we live in a constant drive to find new and better ideas for almost every aspect of our professional and personal circles (Amabile, 1989). The inherent curiosity (Feldman, 1999), search for newness and exploration (Urban, 1991), are constitutional to human behavior, initiating in early childhood and never really wearing off. Creativity during childhood is positively associated with adaptation, development, learning, and growth (Gardner & Gardner, 2008) and appears to be a predictor of creativity in adulthood (Ayman-Nolley, 1992; Russ, 2016).

One could expect that creativity increases with age, as we mature cognitively and accumulate experiences. However, fluctuations in creative abilities across childhood and adolescenthood are reported in the literature (Kim, 2011) and reasons behind these fluctuations are being carefully analyzed in recent literature (Said-Metwaly et al., 2020; Barbot, & Said-Metwaly, 2020).

The present review provides a systematic summary of evidence about creativity interventions dedicated to children. Creativity research lacks an understanding of existing programs for creativity stimulation in children and the effectiveness of such programs. This holds true especially for interventions focused on children where the research appears scattered, hindering researchers from searching, selecting, and applying these interventions. By providing a systematic summary of evidence of creativity interventions, we can better understand how creativity is being measured and the efficacy of the programs. The results from this work also inform policy makers and practitioners about evidence-based intervention aiming at creativity stimulation (Beelmann, 2006).

Additionally, there is a need to classify creativity interventions according to a structured level of analysis as different terms, labels, expressions, and definitions have been used interchangeably in the field of creativity (Abdulla & Cramond, 2018; Ivcevic, 2009). Indeed, scholars recognize the difficulties in reaching a consensus about how to classify creativity (Runco et al., 1998). This systematic review contributes to the clarification of levels of analysis of creativity interventions by extending a coding scheme initiated by Scott et al. (2004a). The research question for this work is: *What characterizes interventions that foster creativity in children?*

Creativity Landscapes

In this section, we provide a review of creativity research, theories of creativity development, and of existing interventions in creativity.

Creativity Definition(s)

Creativity is a multi-faced concept and is now a thriving field of research (Ford & Harris III, 1992; Kaufman & Sternberg, 2010; Parkhurst, 1999; Runco et al., 1999; Sawyer, 2011; Sternberg, 1988; Sternberg & Kaufman, 2018; Sternberg & Sternberg, 1999; Taylor, 1988). The definition of creativity has changed over time contributing to a field of research with a rich but sometimes problematic terminology (Sternberg & Sternberg, 1999). Researchers have different viewpoints as to what creativity is (Kampylis & Valtanen, 2010; Puryear & Lamb, 2020). The absence of a common definition that is accepted may be partially responsible for the proliferation of alternative theories that can sometimes hold contradictory ideas (Kozbelt et al., 2010; Lubart, 2001). As such, over 60 definitions of the concept of creativity are present in the field of psychology alone (Mayer, 1999; Taylor, 1988).

While earliest definitions of creativity described this concept as a function of an individual ability (Guilford, 1967), recent definitions view creativity as an interaction of many factors, including the individual and environment (Plucker et al., 2004). Table 1 summarizes

selected definitions of creativity in a timescale manner. A recent work by Puryear and Lamb (2020) replicated a previous study by Plucker et al. (2004) and investigated if creativity has been explicitly defined in previous peer-reviewed published articles and what is the degree of definitions attributed to this concept. The authors concluded that the level of explicitness in creativity definitions increases over time in peer-reviewed published articles (in a total of 600 screened articles, 35% explicitly defined creativity in 2004 and 56% in 2016), suggesting a notable improvement in reporting the definition of this concept. We want to highlight that despite this improvement, explicit definitions of creativity are still scarce and show the complex ongoing debate in the field. Related to this, the same author also showed that the elements present in creativity conceptions vary and are strongly field-specific. As such, articles from psychology are drawn to include psychometrics conceptions, and articles from education are likely to rely on elements of problem-solving to define creativity (Puryear & Lamb, 2020). This seems to show that variations in creativity definition do not only exist due to disagreement but also due to the variance of context for which creativity is being put into use. According to Puryear and Lamb (2020), definitions of creativity should be nuanced according to the application context, and the variations in definitions should be constrained to the margins and these nuanced contexts.

While defining creativity remains an "Achilles heel of creativity research" (Puryear & Lamb, 2020, p. 1), there is an agreement that certain elements of creativity, including uniqueness and usefulness, are commonly associated with definitions of this concept despite the application field (Plucker et al., 2004; Puryear & Lamb, 2020). The work of Puryear and Lamb (2020) revealed that in the field of education, creativity has been associated with notions of problem-solving, artistic abilities, and creativity as a teachable skill. In this systematic review, we position our definition of creativity in relation to education since we focus on children. Therefore, we define creativity as a *process* can that be nurtured, connect to

the ability to *solve-problems and find solutions*, and related to variables of the *creative person*, including self-expression.

Creativity Development

Freud (1959) was the first to propose that childhood is filled with imagination and fantasies, attributes of the creative thought, which have the potential to grow into adulthood. Creativity was also regarded in light of a constructionist approach in which children need to pass various developmental stages, usually in a fixed order, for creative growth (Piaget, 1959, 1971; Piaget & Cook, 1952). Aligned with Piaget's theory of development, Vygotsky (1980, 1990, 2004) considered "any human act that gives rise to something new is referred to as a creative act", in which learning — including creative acts — is dependent on the interpersonal context of development.

Creative growth has different peaks over a lifespan, not being a steady-state or consistently increasing (Claxton et al., 2005; Dacey, 1989; Feldman, 1999; Kogan, 1973; Runco & Cayirdag, 2006; Sawyer et al., 2003; Spodek & Saracho, 2014). Despite it has been accepted in the literature that creative abilities decrease in certain ages ("creativity slumps") and creative abilities decrease across generations ("creativity crisis") (Kim, 2011), these decreases have been questioned and re-framed in recent literature. A meta-analysis by Said-Metwaly et al. (2020) clarified that the fluctuations in divergent thinking, defined as the generation of multiple relevant and original alternative answers in response to a single problem, depend on many factors that should be carefully considered, namely gender, country, intellectual giftedness, and the type of divergent thinking test that is applied. With this, the authors meta-analyzed the controversial line of research findings related to "creativity slumps" and revealed that there is more to this discussion than what initially could be conceptualized, including controlling demographic factors specific to children and adolescent population that can be driving the results that show decrease in creative abilities. Additional research related to

fluctuations in creative abilities highlight the importance of looking into variables such as formal education and conformity rules (Gardner & Gardner, 2008; Nash, 1974; Runco et al., 2017; Runco & Cayirdag, 2006; Torrance, 1968), biological changes (Gardner, 1982; Kohlberg, 1966; Runco & Charles, 1993), developmental transitions related with cognitive sophistication (Piaget, 1950; Smith & Carlsson, 1983; Vygotsky, 1987, 1990), mental health, and economic factors (Florida, 2004; Gabe et al., 2012).

When re-analyzing the data of Kim (2011), by considering updated normative values from the last Torrance Test of Creativity Thinking (TTCT-Figural), Barbot and Said-Metwaly (2020) concluded that the notion of creativity decline was grounded on problematic empirical decisions, statistical approaches, data representation, and interpretation of findings. This seems to show that the operationalization of a "creativity crisis" is based on a rather narrow operationalization of the phenomenon and raises issues about the conceptualization and the measurement of creativity, which might need to be expanded beyond the "golden standard" of using the TTCT for creativity measurement (Barbot, & Said-Metwaly, 2020). However, research has shown that creativity is a skill that can be trained, with interventions presenting encouraging levels of effectiveness (Birdi, 2016; Ma, 2009; Mansfield et al., 1978; Rose & Lin, 1984; Scott et al., 2004a).

Creativity Interventions

Given the concern about the decrease in creativity, several interventions have been developed to nurture and stimulate this ability. Scott et al. (2004b) presented a review about the effectiveness of creativity training programs, demonstrating that different types of training had value on their own but with varying levels of effectiveness. Additionally, Ma (2009) conducted a meta-analysis to identify the most relevant variables associated with the creative person, the creative process, the creative product, and the environment. However, both reviews were general and not focusing on children, which limits the understanding of the type

of interventions for this target group. For children in particular, Davies et al. (2013) and Gajda et al. (2017) conducted systematic reviews to investigate the learning environments that promote creativity. Despite its relevance, their work did not focus on interventions or the programs that were specifically developed to stimulate creativity.

Davies et al. (2014) and Chan (2013) also conducted systematic reviews, but their focus was on teacher's roles in promoting students' creativity. Additional systematic reviews and meta-analyses were conducted but all in all, existing literature does not provide a comprehensive summary of existing interventions for creativity.

Method

Protocol and Registration

A systematic review is conducted to investigate evidence-based interventions (Beelmann, 2006). We used the PRISMA-P (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol to report our findings (Moher et al., 2015). The PRISMA-P checklist document about our systematic review can be found as supplementary material in Open Science Framework (OSF) (Alves-Oliveira et al., 2020). The protocol was also preregistered in the International Prospective Register of Systematic Reviews (PROSPERO, registration number: CRD42016052101).

Eligibility Criteria

- **Study characteristics.** PICOS framework was used to describe the inclusion and exclusion criteria according to the Population (P), Intervention (I), Comparison (C), Outcome (O), and Study design (S) (Schardt et al., 2007).
- **Population —** *Inclusion:* children between 5-13 years old. *Exclusion:* studies with restricted populations such as children with physical (e.g., motor disabilities), mental disorders (e.g., autism spectrum disorder) or gifted; and children with different age ranges, unless the average age is within the scope of our age criteria.

- **Intervention —** *Inclusion:* literature reporting the outcomes of creativity interventions on creativity. *Exclusion:* studies that only investigated effects of other interventions (e.g., arts and crafts activities) on creativity, or investigated the relation or effects of creativity on other outcomes (e.g., reward, instruction, affect/emotion).
- **Comparison —** *Inclusion:* no intervention, different treatment, control group, pretest, and post-test measures. *Exclusion:* n/a.
- **Outcomes —** *Inclusion:* quantitative (statistical) results reporting the effect of creativity interventions on creativity levels. Results can include both quantitative and qualitative results if qualitative findings are meant to deepen the understanding of the quantitative results. *Exclusion:* articles of exclusively qualitative and/or theoretical approach.
- **Study design —** *Inclusion:* experimental studies presenting the methodological design, including sample size, measures, and statistical analyses. Detailed Interventions to enable replication, that is, must describe the techniques used to foster creativity and validated instruments to assess creativity outcomes. *Exclusion:* literature lacking the description of the intervention or information about the study design.
- **Report characteristics.** The present systematic review includes articles from 1950−2020. We included articles from 1950 because it is the date when Guilford highlighted the need in studying creativity empirically in the American Psychological Association (Guilford, 1950). We included peer-reviewed articles written in English and Portuguese, but excluded grey literature (e.g., opinion pieces), book chapters, dissertations, abstracts, and technical reports.

Information Sources

We started our search by reading systematic reviews and meta-analyses (Cropley, 1997; Jaušovec, 1994; Mansfield et al., 1978; Nickerson, 1999; Scott et al., 2004b). Hand-search was performed by consulting the citations to identify candidate articles of interest for the present systematic review. The most recent systematic review on creativity programs is from 2004. The novelty of our systematic review is that it summarizes evidence of interventions and/or creativity training programs exclusively dedicated to children at elementary school age as children are in a key-stage where creativity can be nurtured and developed.

A more complete search was performed using the following electronic databases: ISI Web of Science, Scopus, PubMed, and EBSCO. Using EBSCO, we searched the following databases: PsycARTICLES, ERIC (Education Resources Information Center), Psychology and Behavioral Sciences Collection, PsycINFO, and MEDLINE. Google Scholar search portal was additionally used to identify publications not indexed in the above-mentioned databases. Other Publishers, such as the Institute of Electrical and Electronics Engineers (IEEE) and the Association for Computing Machinery (ACM) were consulted. Additionally, we searched for articles that focused on the topic of this systematic review in the following selected journals: "Psychology of Aesthetics, Creativity, and the Arts", "Journal of Creative Behavior", "Thinking Skills and Creativity", "Creativity Research Journal", and "Creativity Studies". The same procedure was conducted for selected conferences of interest: "International Conference on Computational Creativity", "Creativity & Cognition Conference", and "International Conference on Design Creativity". This last step was to perform a hand-search on the references of these articles and select articles not identified in previous searches. For all the selected articles, duplicates were then removed. Data collection ceased when we reached saturation, which occurred when all the new identified articles already existed in the database no matter how many more articles were hand-searched (Morse, 1995).

Finally, we contacted several authors working on the field of creativity to avoid the file-drawer problem, which is considered the tendency of researchers to not submit articles with null results, or for journals to only publish studies with statistically significant results (Rosenthal, 1979). Therefore, 35 authors were contacted via email and asked whether they were aware of unpublished or ongoing studies in the scope of this systematic review, with 12 scholars returning responses; however, no author provided additional articles to include in this systematic review.

Search Strategy

Query terms used for this systematic review included the title, the abstract, and the body of the articles. Our search algorithm was composed of combinations that include Boolean and proximity operators, wild cards characters or truncation operators, and MeSH terms (Medical Subject Headings), the latter is a comprehensive controlled vocabulary for the purpose of indexing journal articles and books in the life sciences. The search code used included the following: (“creativity”) AND (“program” OR “train*” OR “promot*” OR “enhanc*” OR “develop*” OR “measur*” OR “evaluat*”) AND (“child*”). Additional search codes were used in different databases because of distinct search engines. The full list of the search codes organized by databases is present in supplementary Table 3.

Study Records

Data management. Endnote from Clarivate Analysis was used for citation management of the searches (Bramer, et al., 2016). A literature search was uploaded from Endnote to the Covidence Software (Babineau, 2014), an Internet-based software program that facilitates collaboration among reviewers during the selection of articles to be included in the systematic review.

Selection process. The search process returned a total of 4531 publications. A flow chart of the literature selection process is illustrated in Figure 1. From the total pool of articles,

1102 through citations from previous systematic literature reviews and meta-analysis, 61 through ISI Web of Science, 1410 were identified through PsycARTICLES databases, 545 from selected journals and conferences, 119 with PubMed, 73 through SCOPUS, 70 through IEEE and ACM publishers, 1151 using Google Scholar portal. From this pool of publications, 559 articles were identified as duplicates, resulting in a total of 1944 articles after duplicates removal. Title and abstract from these articles were screened by judging against the eligibility criteria, resulting in 2492 articles excluded during screening and deriving in 377 articles assessed for eligibility. After full-text reading, 316 articles were excluded after comparing them to the inclusion criteria. The final sample of included articles for this systematic review was 61. The search started in 2016, was updated in 2018 and 2020.

Data items. From the selected articles, we extracted the descriptors of the interventions (see details in Table 2). We developed a coding scheme that characterizes the different levels of analysis of creativity interventions (see Figure 2 and supplementary Table 5).

Quality Assessment. Criterion for quality assessment was defined according to methodological recommendations of the Strengthening the STROBE Statement (Reporting of Observational Studies in Epidemiology) (Von Elm et al., 2007). Each article was assessed for study design, setting, participants, variables, data sources/measurement, bias, study size, quantitative variables, and statistical methods (see supplementary Table 4).

Taxonomy of Creativity Interventions

We have performed a deductive coding scheme to systematize these levels by combining prior definitions developed by researchers in this field with concepts that lacked formal definition. In essence, our coding scheme proposes a taxonomy of creativity interventions that properly defines key-terms of creativity training and can be used in a comprehensive way to both serve and understand research on creativity.

Coding Procedure

Scott et al. (2004b) classified creativity interventions according to *cognitive processing skills, training techniques, delivery media, and practice exercises*. Following this classification system, two independent coders coded the interventions. However, during the coding process, coders encountered attributes of interventions that were not represented by Scott et al. (2004b)'s codification system. Therefore, the following new elements were added: *target, ambient, administrator, and dimension*. The final result was a Taxonomy of Creativity Interventions with eight levels of analysis described in supplementary Table 5 and visually represented in Figure 2.

Thus, each intervention was coded in terms of the cognitive processing skills (11 categories), training techniques (17 categories), delivery media (18 categories), practice exercises (12 categories), target (4 categories), ambient (4 categories), administrator (7 categories), and dimension (3 categories). All categories are represented in Figure 2. Interventions could be coded to more than one category if they focused on different aspects of creativity, e.g., an intervention could be coded for *flexibility and originality*, both categories belonging to the cognitive processing skills (see supplementary material for coding details).

To ensure consistency across coders, calibration exercises were performed until stability was reached (Krippendorff & Bock, 2009). When the initial set of articles was coded, the coders met to solve discrepancies (Campbell et al., 2013). They compared their coding scheme to ascertain concordances (i.e., alignment in definitions, language, and coding logic). Whenever there were discrepancies, the "negotiation agreement" was used and they verbally discussed with a mutual effort to reconcile disagreements and divergence (Garrison et al.,2006; Hoyle et al., 2002). Negotiations between coders regarding data collection were timed and lasted around 146.5 hours.

Results and Discussion

Discussing Creativity Interventions

By analyzing Figure 3, we can see that the most stimulated *cognitive processing skill* was idea generation (18%), followed by flexibility (14%), idea evaluation (11%), and conceptual combination (11%). When looking at the *training technique* mostly used by the interventions, we can see that divergent thinking (15%) was highly used, followed by expressive activities (11%), and elaboration of ideas (9%). These results seem to show that creativity training programs for children were developed taking into account diverse types of creative elements, which means that different programs with different creativity focus are part of the currently available research.

In terms of how the creativity programs are delivered to children, we can see in Figure 3 that the most common *delivery media* is programmed instruction (28%) in which an administrator gives verbal instructions to participants about sequential steps to follow in the program. This is followed by discussion (16%) and cooperative learning (9%). Additionally, when looking at the types of *practice exercises* delivered by these programs, we can see that children frequently engage in imaginative exercises (18%), in classroom (15%), and group exercises (14%). These results seem to show that while the chose delivery media is more structured because programs are delivered using programmed instruction, the types of exercises that children engage in promote their imagination and fantasy, as they engage mostly in imaginative exercises. This result seems aligned with the notion that structure combined with a free space for creation can have positive effects on creativity expression (Sagiv et al., 2010).

Results also showed that most of the creativity intervention programs seem to focus on the creative person, adopting a pre-post test study design, using tests to measure the effects of an intervention (83%). Only a few programs dedicated the evaluation to the creative process (9%) or the creative product (8%). This shows that the majority of the knowledge generated in terms of the effects of the programs in children's creativity research is measured only in terms of tests.

While they can bring important measurement results, it is well known that the creative process is also an important variable when measuring creativity, especially regarding children, and tests fail to capture these effects (Resnick, 2007). Additionally, because tests are mostly domain-dependent (e.g., drawing tests are especially as younger children do not master writing comprehension) the applied tests that evaluate a given intervention might not be able to fully grasp the effect the program has on the creative abilities in other domains.

When it comes to the *administrators* of the creativity programs, we can see that teachers are the main administrators (44%). This makes sense since the school is the ambient where most of the programs are applied (89%). While this may come across as beneficial since it accounts for ecological validity, teachers need to be trained by researchers to apply the creativity programs. This adds a burden for the teacher, which can compromise the adherence of participating in studies leading to a lack of sample representation. Additionally, teachers learn to apply a program that is not recognized by the Ministry of Education, which means that the chances to have long-lasting creativity programs implemented in school is low.

We can also see in Figure 3 that some programs are being developed promoting independence of use, which means that participants can use the training program mostly on their own, without depending on external administrators (27%). This was a surprisingly positive result and most of the programs that are designed for the independence of use rely on technologies (e.g., apps, computers, social robots), as *delivery media*. This seems to show an investment in designing and developing technology to promote creativity, which is a novel step in creativity research. Additionally, it shows that children are empowered to use the programs by themselves with the aid of technology, not depending on external administrators to understand the activities they need to accomplish in a training session. Since creativity benefits from a sense of independence of use, the combination with technology as a new tool for creativity programs seems to bring this independence and thus reveals to be beneficial and desired. In addition, the

programs are mostly delivered groups (68%), with some programs having an individual application component (23%). The fact that group support systems for creativity are prevalent comes across as an important result since groups stimulate collaboration during creation (Gabriel et al., 2016). Additionally, individual support systems are also importantly present since some decisions and creative work are still performed individually. Hence, individual creativity support systems are quite relevant and the combination of both seems ideal to exit (Wang, & Nickerson, 2017).

Limitations and Future Research Directions

The limitations of each study included in this systematic review (see Table 2 for details on limitations) opened doors for new research directions and possible policy-making developments in this field. The first limitation prominently highlighted in different studies was the usage of a simple metric to measure creativity, and the metrics used are usually to evaluate the creative person. A research direction that can emerge from here is the need to develop additional metrics to evaluate creativity focused on the *creative process*. Related to this, additional metrics are needed to measure the efficacy of *long-term programs for creativity* since the majority of used measures are single-use and cannot represent the rich dynamics of long-term creative stimulation. Although several programs are addressing the long-term stimulation of creativity, they lack proper longitudinal measures of creativity evaluation.

The second limitation voiced in the studies referred to a lack of deeper understanding of the relationship between creativity and other variables. While the studies tried to control for person-related factors (e.g., personality, intrinsic motivation), little is known about the impact of press or environment variables on creativity. Especially, studies voiced the need to understand cultural influences on creativity intervention programs. Therefore, studying how culture can influence creativity, especially culturally dependent perceptions of creativity is crucial for future research.

The final limitation pointed by the studies mentions a lack of proper time to train the administrators of the creativity interventions. As seen in the results, the majority of the administrators of these programs were teachers and the majority of the programs occurred in the school ambient. Teachers are known to suffer from burnout due to emotional exhaustion and additional work-related variables. Burnout levels in teachers are visible across different countries, removing them, from being the ideal administrators of programs (Garcia-Arroyo, et al., 2019). A new research direction that can emerge from here is the training of other administrators, such as children themselves which can promote empowerment and independence in children when it comes to creativity expression and understanding. Another promising administrator can be family elements, such as parents, siblings, and even grandparents. Including the family nucleus in creativity promotion can enhance intergenerational activities and promote novel ways for the family to connect. While we are not excluding teachers from the role of administrators, their inclusion requires a change in educational policies around creativity, by formally acknowledging creativity as an essential and required ability to be stimulated in school. While some countries already started adopting creativity as a learning outcome to be developed in schools, this is not true for the majority of the countries across the globe (Hui & Lau, 2010).

Implications and Conclusion

Our systematic review focused on programs for creativity spanning 70 years of research. To evaluate the interventions, we have developed a coding scheme to analyze the creativity programs/interventions, which we called “Taxonomy of Creativity Interventions”. This Taxonomy is meant to be broadly used to either (1) design new creativity programs, (2) apply existing ones, (3) or compare the efficacy between interventions. As outlined throughout this paper, the reasoning that creativity is an essential skill to nurture stands as the biggest motivation to carry out a detailed classification of existing interventions.

Our classification system builds on the one initiated by Scott et al. (2004b) and extends it by proposing new levels of categorization that promote a more detailed representation of the interventions. We envision that our classification can be used to promote the design of future creativity interventions. Having an explicit classification system like the one we provided in this paper will enable a more informed way to design interventions that target specific aspects of creativity that aim to be developed and/or stimulated. For example, by using this classification system we can see that most of the interventions with children used 'programmed instruction' and only a few interventions used toys or technology. While programmed instruction can be easier to use, we also argue that in day-to-day life, being able to stimulate creativity using toys or emerging technologies (such as social robots or computers) can be more compelling for children and might be a better delivery method for creativity programs. This is because toys are the usual tools of children and because they are naturally compelled to use technological devices (Mantilla, & Edwards, 2019). While this can be challenging to implement, we argue that this is a crucial way to move forward in creativity research for children. We envision that this will require a multidisciplinary team effort where psychologists and engineers work together to create new tools for creativity interventions that are more suitable and interesting for children and for contexts of education that are inclusive of creativity practices.

Additionally, we defined each category of the classification system as an attempt to bring a more explicit understating over creativity research. We argue, however, that classifications in the field of creativity research are challenging to perform, as multiple definitions exist surrounding the same concept. Therefore, while we have tried to best define each category, we acknowledge the limitations of the definitions, and we see this as a work in progress that researchers in the field of creativity are making towards a clearer, inclusive, and solid language to talk about creativity. It is important to move towards this direction, otherwise,

we fall into the fallacy of replicating older methods and measurements which narrows the notion and role that creativity can have in our lives. For example, a lot of studies have used multiple sessions to train children for creativity, but there is still a lack of understanding and measurement about creativity progression (or long-term interventions for creativity). We argue that creativity should be seen as a *practice* and that it will be important to establish new ways to measure success during the *practice of creativity*. For this, we can draw inspiration from the art field, such as music learning practice, where students are evaluated by repertoires of learning, i.e., separated stages of music learning, e.g., how they organize information and how they integrate it with existing knowledge (Nielsen, 1999). By developing repertoires of creativity practices, we can better understand and evaluate how the success of long-term interventions would look like.

In sum, this systematic review highlighted the development of creativity intervention programs for children from 5—13 years old. We concluded that there was an effort to design and develop programs for children that showed promising levels of effectiveness. While we highlighted the trends of the programs, limitations and promoted dialogue about new research directions in this field, additional research is required to assess the efficacy of the different programs. We hope this work provided a useful overview of efforts made in creativity research for children, and that new research questions and studies can be derived from our findings.

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NOTE: References marked with an asterisk indicate studies included in this systematic review.

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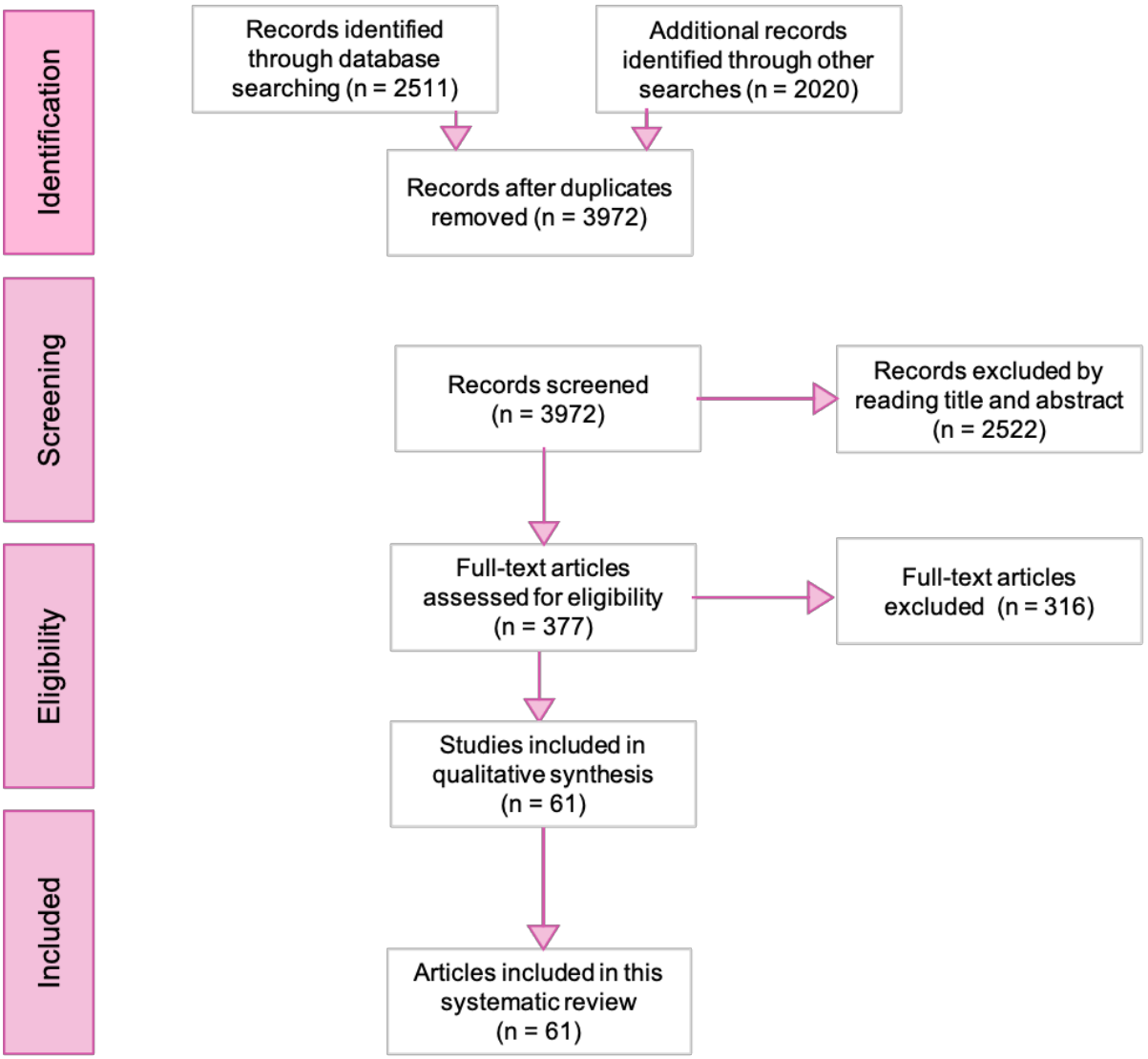

Figure 1. *Flow chart of data collection of articles, according to PRISMA-P guidelines (Moher et al., 2015).*

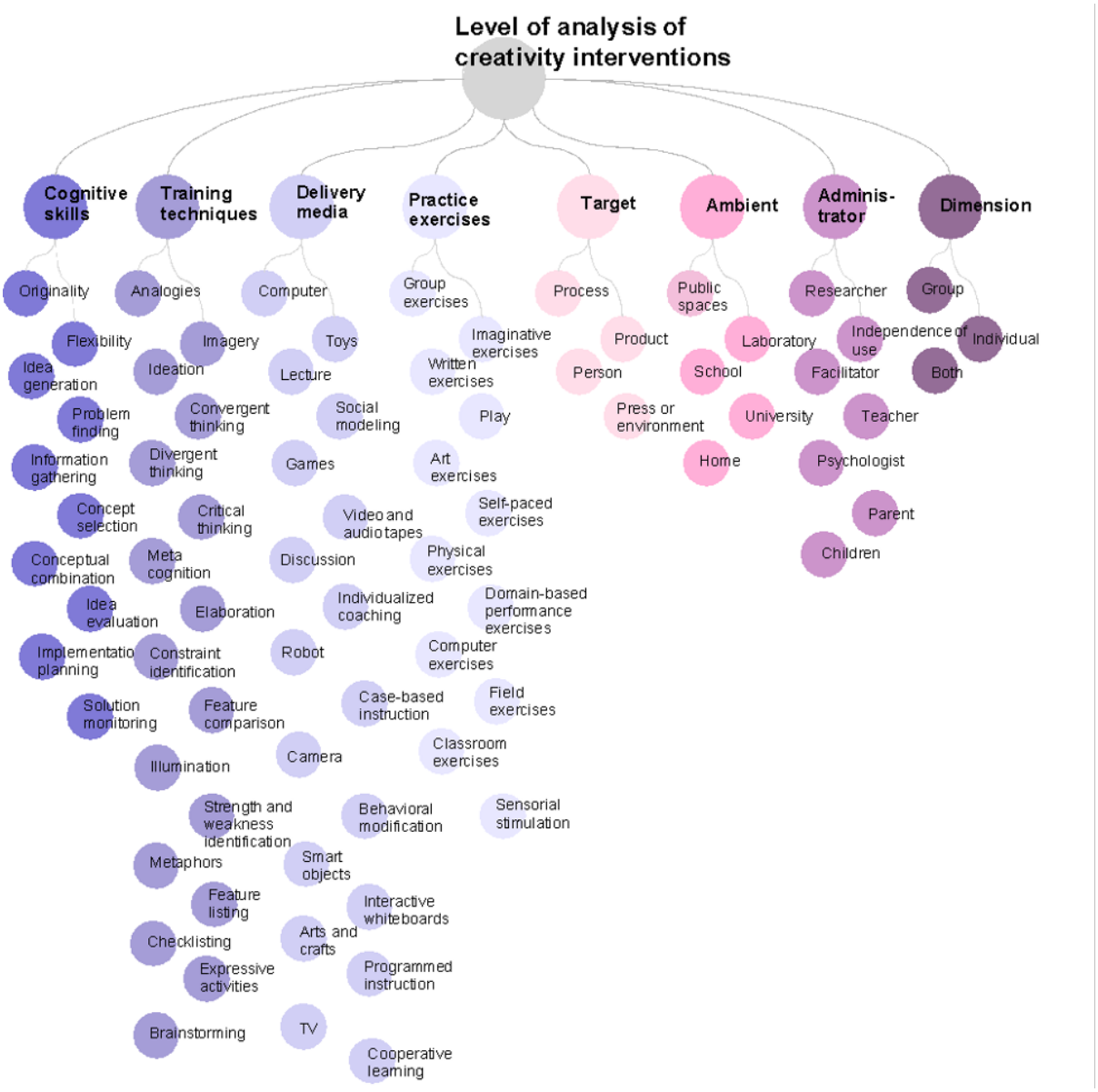

Figure 2. *Taxonomy of Creativity Elements proposed by this systematic review.*

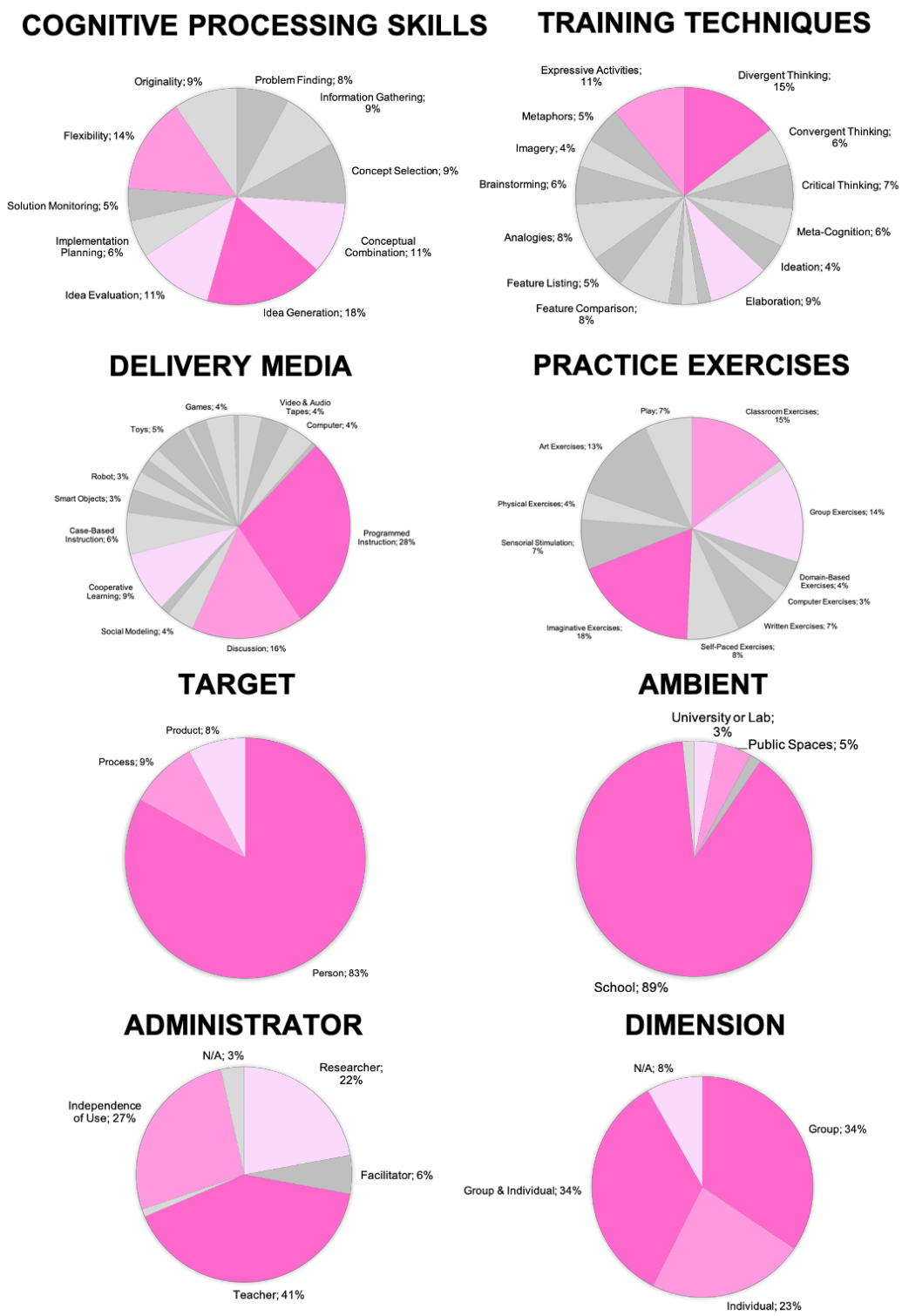

Figure 3. *Results of the attributes of creativity from the creativity training programs included in this systematic review (in percentage). The color palette varies from deep to light pink to show the most used elements. Grey colors show the least used elements. Elements with 2% or less were excluded from the caption.*

Table 1. *Summary of selected definitions of creativity in timeline order.*

Author(s)	**Creativity definition**
Guilford (1967)	Embodiment of a thought in the form of an external behavior with 3 characteristics: fluency, flexibility, and originality.
Torrance (1988)	Series of flows, including problem identification, speculation, construction of hypothetical assumptions and creation, and the sharing of ideas with others.
Amabile (2018)	Process of idea generation or problem solving and the actual idea or solution being a function of the person's expertise, creative-thinking skills, and motivation.
Sternberg and Lubart (1996)	Creative performance occurs in the interaction of 6 intellectual abilities, knowledge, thinking styles, personality, motivation, and environmental elements.
Boden (2004)	Composed of two types of creativity: Psychological (P) and Historical (H). P-creativity involves coming up with a surprising, valuable idea that's new to the person who invented it; an idea is H-creative if no one else has had it before and it has arisen for the first time in human history.
Baer and Kaufman (2005)	Explained by the Amusement Park Theory in which creativity weaves both domain-general and domain-specific factors supporting creative performance with a hierarchical structure.
Csikszentmihalyi (1999), Kaufman and Beghetto	Explained by the Four C Model of Creativity: mini-c involves any learning acquisition; little-c are everyday problem solving and creative expression; Pro-C are creative ideas exhibited by

(2009), Simonton (2010)	professionally expert people in a professional venue; Big-C occurs when creativity is considered great in the given field.
Sawyer (2017)	Group emergence where flow, collaboration, and improvisation processes take place. When group synchrony is reached, it becomes difficult to discriminate the individual contribution of each person, as “the whole is greater than the individual parts'”.
Cronin and Loewenstein (2018)	Process of following cues to generate insights that change our perspectives, which with craft we can use to form inventions and enlightenment.

Table 2. *Profile of the creativity intervention programs included in the current systematic review.*

Ref.	**Sample N, gender, age**	**Dur. (N sessions)**	**Controlled factors**	**Intervention**	**Measures**	**Findings**	**Limitations**
Feldhusen, Bahlke, and Treffinger (1969)	256, n/a, 8-12	23	Grade, gender, intelligence quotient	EX: Radio Series Program; CT: No intervention	Minnesota Tests of Creative Thinking	EX > CT	n/a
Shivley, Feldhusen, and Treffinger (1972)	377, n/a, 10-11	18	Creative abilities of the teachers	EX1: Purdue Creative Thinking Program; EX2: Productive Thinking Program w/ discussion; CM1: Purdue Creative Thinking Program with discussion; CM2: Productive Thinking Program w/ discussion	Torrance Test of Creative Thinking and Childhood Attitude Inventory for Problem Solving	EX1, EX2 > CM1, CM2; EX1 < EX2	n/a
Dansky and Silverman (1973)	90, both, 4-6	1	Ethnicity, socioeconomic status	EX: Free-play; CM: Imitation of object manipulation; CT: Painting activity	Alternate Uses Test and behavior analysis	EX > CM, CT; CM = CT	n/a
Alencar, Feldhusen, and Widlak (1976)	578, n/a, 9 − 11	14	Gender, grade level	EX: Purdue Creative Thinking Program; CM: Purdue Creative Thinking Program with reinforcement;	Torrance Test of Creative Thinking	EX, CM > CT; EX > CM	Only one metric was used to measure creativity

				CT: No training and no reinforcement			
Houtz and Feldhusen (1976)	240, n/a, 8-9	45	Ethnicity, socioeconomic status	EX: Purdue Elementary Problem Solving Inventory; CM: Purdue Elementary Problem-Solving Inventory with reward; CT: No training and no reward	Purdue Inventory and Transfer test with open ended problems	EX, CM > CT; EX > CM	Children got used to the reward time, removing the intervention main effect and purpose
MacDonald, Heinberg, Fruehling, and Meredith (1976)	96, n/a, 10-11	1	Sociological type, gender, academic achievement	EX: Training of Original Responses; CT: Self-selection of activity	Original responses after intervention and after 10 months, and making inferences test	EX > CT	n/a
Moreno and Hogan (1976)	218, both, 10-12	15	Gender, race, social-class level, IQ, reading comprehension level	EX: Productive Thinking Program; CT: Gates-Peardon Reading Exercises	Torrance Test of Creative Thinking	EX > CT	n/a
Franklin and Richards (1977)	119, n/a, 9-10	6	Children: age, IQ, socioeconomic status; teachers: teaching style; schools:	EX: Divergent Production Exercises; CT: Artistic work	Wallach and Kogan Tests of Alternate Uses, Similarities, Line Meanings, and	EX > CT	n/a

			classroom environment		Instances, Torrance Test of Creative Thinking, Guilford Test of Statements and Questions		
Goor and Rapoport (1977)	142, both, 11-13	20	Children: disadvantaged background; administrator: age, socioeconomic status	EX: Creativity Games; CT: No intervention	Torrance Test of Creative Thinking and Origence and Intelligence of the Welsh Figure Preference Test	EX > CT	n/a
Huber, Treffinger, Tracy, and Rand (1979)	648, n/a, 8-12	12	Gifted children, ethnicity, socioeconomic status, IQ, performance, developmental factors, gender, race	EX: Purdue Creativity Training Program; CT: No intervention	Torrance Test of Creativity Thinking	EX > CT	Teachers lack training to implement the creativity programs; students seem to lack training in self-directed learning
Cliatt, Shaw, and Sherwood (1980)	37, both, 5-6	8	Children: socioeconomic status;	EX: Divergent Thinking Questioning; CT: No training	Torrance Test of Creative Thinking	EX > CT	n/a

			teachers: performance when applying the creative training				
Dansky (1980)	96, both, 4-8	1	Socioeconomic status, equal distribution of players and nonplayers across conditions	EX: Free play with make believe; CM: Problem-solving with objects; CT: Imitation of object manipulation	Alternate Uses Test	EX > CM, CT	Lacks deeper study of the relationship between play and fluency and its duration effects
Haley (1984)	89, both, 4-6	42	Age, gender, socioeconomic status	EX: Sociodrama; CM: Verbal Training Method; CT: No Training	Torrance Test of Creative Thinking, and Thinking Creatively in Action and Movement Test	EX, CM > CT; EX > CM	n/a
Baer Jr (1988)	48, n/a, 12-13	3	School achievement, socioeconomic status	EX: Osborne-Parnes Creative Problem Solving; CT: No intervention	Divergent and convergent thinking tests	EX > CT	Dropout of students from the study due to its long-term evaluation
Clements (1991)	73, both, 8	75	Socioeconomic status, ethnicity, achievement	EX: LOGO computer programming; CM: Computer exercises; CT: No intervention	Torrance Test of Creative Thinking	EX > CM, CT; EX, CM > CT	n/a

Nelson and Lalemi (1991)	40, n/a, 7 – 12	6	n/a	EX: Imagery training; CT: No training	Torrance Test of Creative Thinking	EX > CT	n/a
Flaherty (1992)	45, both, 8-9	12	Age, gender, IQ, socioeconomic status	EX: Holistic Creativity Program; CT: No intervention	Torrance Test of Creative Thinking, and Creativity Assessment Packet	EX > CT	n/a
Meador (1995)	107, n/a, 6	24	Giftedness of children	EX: Synectics Training; CT: No intervention	Torrance Test of Creative Thinking	EX > CT	n/a
Baer (1996)	157, n/a, 12-13	8	n/a	EX: Divergent-Thinking Program; CT: Arts' classes	Consensual Assessment Technique	EX > CT	n/a
Krampen (1997)	40, both, 8-10	1	Age, grade, gender, previous experiences with systematic relaxation exercises	EX: Systematic Relaxation Program; CT: Relaxation without instructions	TDK for ideational and associative fluency	EX > CT	n/a
Antonietti (2000)	450, n/a, 5-7	52	n/a	EX1: Real life Analogies; EX2: socioemotional Analogies; EX3: Text Analogies; CT: No intervention	ABCD Test, Story Test, Problem Test, and Association Test	EX1, EX2, EX3 > CT	n/a

Luftig (2000)	615, both, 7-11	1 academic year	Ethnicity, economic status	EX: SPECTA+ program; CM: Innovative Program; CT: No intervention	Torrance Test of Creative Thinking	EX > CM, CT	n/a
Fleith, Renzulli, and Westberg (2002)	217, both, 8-12	15	Socioeconomic status, bilingual monolingual children	EX: New Directions in Creativity Program; CT: No intervention	Torrance Test of Creative Thinking	EX > CT	Small sample size; cultural differences were not considered
Majid, Tan, and Soh (2003)	60, both, 10-11	5	Academic performance, language proficiency, competence in writing	EX: Writing with SCAMPER; CM: Writing with Internet; CT: Normal writing task	Language Creativity Score Sheet; Creativity Rating Scale	CM > EX, CT	n/a
Garaigordobil, and Landazabal (2005)	86, both, 10-11	1 academic year	Age, gender, academic aptitude, achievements, socio-cultural level	EX: Prosocial and Creative Play Program; CT: Ethics and arts exercises	Word Association Test and Kaufman Brief Intelligence Test	EX > CT	Lack of controlled characteristics of program administrators and setting's variables
Garaigordobil (2006)	86, both, 10-11	1 academic year	Children: age, gender, academic aptitude, achievement, socio-cultural level; parents: socioeconomic	EX: Cooperative-Creative Play Program; CT: plastic arts	Torrance Test of Creative Thinking, and Creation of a painting	EX > CT	Lack of controlled characteristics of the program administrator and setting's variables

			status, educational background				
Hui and Lau (2006)	126, both, 7-9	16	n/a	EX: Drama Project; CT: No intervention	Wallach-Kogan Creativity Tests, Tests for Creative Thinking-Drawing Production, and Storytelling Test	EX > CT	n/a
Burke and Williams (2008)	178, both, 11-12	8	Socioeconomic status, ethnicity, registered disabilities	EX1: Individual Thinking Skills Program; EX2: Collaborative Thinking Skills Program; CT: No intervention	Thinking Skills Assessment	EX1, EX2 > CT; EX1 < EX2	Lacks control of the disposition to learn thinking skills
Justo (2008)	36, both, 5-6	50	n/a	EX: Creative Relaxation Program CT: Children lie down w/ eyes closed	Thinking Creatively in Action and Movement Test	EX > CT	n/a
Maker, Jo, and Muammar (2008)	1986, n/a, 5-12	3 years	Ethnicity of students and teachers, implementation expertise of teachers	DISCOVER Program	Test of Creative Thinking-Drawing Production	DISCOVER increased creativity over years	Usage of only One instrument to measure creativity; dropouts during

							the study; heterogeneity of the sample; non-expert administrators of measures
Moore and Russ (2008)	50, both, 6-8	5	Ethnicity	EX1: Play imagination; EX2: Play-affect; CT: Puzzle play	Alternate Uses Test	EX1, EX2 < CT	Low power; different program administrators; poor testing conditions
Pagona and Costas (2008)	82, both, 9	36	Activities that influence motor behavior; area of living	EX: Special Physical Education Program; CT: No intervention	Motor Creativity Test	EX > CT	n/a
Cheung (2010)	60, n/a, 5-6	1	n/a	Movement Activity Program	Torrance Test of Creative Thinking	Movement Activity increased creativity skills in children from different schools	Children with limited experience in creative movement; no control condition; no pre-posttest design
Garaigordobil and Berrueco (2011)	86, both, 5-6	1 academic year	Age, gender, academic aptitudes and performance	EX: Cooperative-Creative Play Program; CT: No intervention	Torrance Test of Creative Thinking, and Scale of Creative	EX > CT	Lacks controlled characteristics of the person who administers the program

					Behaviors and Personality Traits		
Smogorzewska (2012)	128, n/a, 5-6	4	n/a	EX1: Storyline Method; EX2: Associations Pyramid Method; CT: Telling stories	Ratings of external judges	EX1, EX2 > CT; EX1 = EX2	Unbalanced conditions; lacks pre-posttest design
Alfonso-Benlliure, Meléndez, and García Ballestros (2013)	44, both, 5-6	6	Age, gender, number of siblings	EX: Creativity Intervention Program; CT: Regular classes	Child Creativity Test	EX > CT	n/a
Dziedziewicz, Oledzka, and Karwowski (2013)	128, both, 4-6	10	Size, type, territorial location of educational institutions, gender, age	EX: Doodle-Book Program; CT: No intervention	Franck Drawing Completion Test, and Torrance Test of Creative Thinking	EX > CT	Priming effect; lacks control of external variables
Akar and Sengil-Akar (2013)	26, both, 10-11	9	School's achievement, age, socioeconomic status	CREACT	Conceptualization, drawing, and painting tasks	CREACT was effective on developing children's creative thinking performance	Lacks control group

Kara, Aydin, and Cagiltay (2013)	90, both, 4-6	1	n/a	EX1: StoryTech Program individual; EX2: StoryTech Program collaborative; CT1: passive toy activity individual; CT2: passive toy activity individual	Story patterns, and number of imaginative objects	EX1, EX2 > CT 1, CT 2	n/a
Dziedziewicz, Gadja, and Karwowski (2014)	121, both, 8-12	30	Size, gender, age	EX: Creativity Compass Program; CT: No intervention	Franck Drawing Completion Test, and Torrance Test of Creative Thinking	EX > CT	Possible priming effect
Smogorzewska (2014)	460, both, 4-5	18	n/a	EX1: Storyline Method; EX2: Associations Pyramid Method; CT: Listen to stories	Behavior analysis of storytelling	EX1, EX2 = CT	Only one measure of creativity; lacks measurement of motivation to perform the study
Gordon, Breazeal, and Engel (2015)	71, both, 3-8	1	Previous interactions with robots	EX: Curious robot; CM: Curious tablet; CT: Non-curious robot	Free Exploration, Question Generation, and Uncertainty Seeking	EX, CM > CT; EX = CM	n/a
Sowden, Clements, Redlich, and	27, both, 9-10	1	Gender	EX: Dance improvisation Program; CM: Command-style dance	Consensual Assessment Technique, and	EX > CM	n/a

Lewis (2015) – Study 1					Product Design Task		
Sowden, Clements, Redlich, and Lewis (2015) – Study 2	34, n/a, 10-11	n/a	Gender	EX: Improvisation Games Program; CT: No intervention	Torrance Test of Creative Thinking	EX > CT	Lacks control for individual differences between participants
Doron (2016)	150, both, 9-13	10	Age, gender, socioeconomic status, religion	EX: Intervention Model for Enhancing Divergent Thinking; CT: No intervention	Tel Aviv Creativity Test	EX > CT	Lacks additional creativity evaluation metrics
Hoffmann and Russ (2016)	42, F, 5-8	6	Ethnicity, socioeconomic status	EX: Pretend Play Intervention; CT: Puzzles, coloring sheets, etc	Affect in Play Scale, Alternate Uses Task, Storytelling Task, and Behavior analysis	EX > CT	Small sample and gender specific
Azevedo, Morais, and Martins (2017)	131, both, 12 − 15	5	Gender	EX: Future Problem Solving Program International; CT: No intervention	Torrance Test Creative Thinking	EX > CT	Lacks control group
Doron (2017)	286, both, 10 − 14	10	Age, gender, socioeconomic status, religion	EX: Intervention Model for Enhancing Divergent Thinking; CT: No intervention	Tel Aviv Creativity Test	EX > CT	Lacks comparison condition

Falconer, Cropley, and Dollard (2018)	184, n/a, 8 – 11	7	Gender	EX: Creative Skills Program; CT: No intervention	The Creativity Measurement Scale	EX > CT	Lack heterogeneous sample and connection between the intervention and teaching
Gursoy, and Bag (2018)	24, n/a, 12 - 13	9	Socio-cultural and economic status	EX1: Creative Thinking Program with Visual Stimuli; EX2: Creative Thinking Program with Audio Stimuli	Torrance Test of Creative Thinking	>EX	Small sample size, lack of control group
Lin, Shih, Wang, and Tang (2018)	50, both, 13 - 15	1	Gender	EX: Executive Functions Training Program; CT: Tetris Game	Unusual Uses Test; Remote Associates Test	EX > CT	Lacks connection of the results with academic achievements and socio-emotional functions
Piotrowski and Meester (2018)	94, both, 8 - 10	20	Gender, parent's job, familiarity and children's usage with digital devices	EX: Moderately Discrepant Apps; CM: Highly Discrepant Apps	Torrance Test of Creative Thinking	EX = CM	Lacks more precise instruments, long-term study, etc
Richard, Lebeau, Becker, Boiangin, and Tenenbaum (2018)	173, n/a, 9	10	Siblings, school repetitions	EX: Creative Exercise Program; CM: Conventional Motor Program	Runco Creative Assessment Battery; Motor Creativity Test	EX > CM	Lack of more analysis on cognitive mechanisms of motor creativity

Ali, Moroso, and Breazeal (2019)	51, both, 6 – 10	1	Gender, Language	EX: Doodle Creativity Game with a Creative Robot; CM: Doodle Creativity Game with a Non-Creative Robot	Torrance Test of Creative Thinking	EX > CM	Activity can be perceived as competitive, removing the collaboration effect
Gu, Dijksterhuis, and Ritter (2019)	172, both, 7 - 12	1	n/a	EX: 5-I Training Program	Alternative Uses Task, Drawing Task, Guessing Task	>EX	Lacks control group, control of cofounding variables such as motivation
Gundogan (2019)	49, both, 5	3		EX: SCAMPER Technique; CT: No intervention	Test of Creative Imagination	EX > CT	n/a
Kim, Choe, and Kaufman (2019)	45, n/a 5	27	Socioeconomic status	EX: Creative Problem-Solving Program; CT: Korean Ministry of Education's Curricular Activities for Character Education	Torrance Test of Creative Thinking, Korean Creativity Traits Checklist, Creative Problem-Solving Checklists, and Decision-Making Ability Test for Young Children	EX > CT	Lacks control of creativity beliefs, additional measures for long-term measurement of creativity
Lucchiari, Sala, and Vanutelli (2019)	224, both, 6 - 10	10	Gender, nationality	EX: Creativity Training; CT: No intervention	Italian Test of Childhood Creativity	EX > CT	Lack controlled factors, such as personality assessment

Ozkan, and Topsakal (2021)	74, both, 13 - 14	7	Gender	EX: STEAM design-based instruction; CM: science curriculum and science textbook	Torrance Test of Creative Thinking	EX > CM	Lacks heterogenous sample, small sample size
Ali, Park, Breazeal (2020)	79, both, 5 - 10	1	Gender, age	EX1: Collaborative Drawing with a Creative Robot; EX2: Collaborative Drawing with a Non-Creative Robot; CM: Collaborative Drawing with Tablet	Torrance Test of Creative Thinking; Test for Creative Thinking Drawing Production	EX1 > EX2	The system lacks the ability to create generative drawings; limitations related with the activity UX
Alves-Oliveira, Arriaga, Paiva, and Hoffman (2020)	62, both, 7 - 8	1	Gender, researcher warmth and competence	EX1: Robot with Creativity Techniques; EX2: Robot with Creativity Techniques and Social Behaviors; CM: Robot Turned Off	CREA, Test for Creative Thinking Drawing Production, Creative Process	EX1 > EX2, CM	Lacks study of creativity in groups

Note. Gender: F = Female, M = Male, Both = Male and Female; Dur. = Duration; Intervention: EX = Experimental condition, CT = Control condition, CM = Comparison condition. Limitations are stated as presented in the papers.