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ORIGINAL

UBUIngenio: extracurricular enrichment programme for the improvement of high ability students' creative thinking

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Creativity, High Ability, project-based learning, creative thinking, extracurricular enrichment programme

Abstract Background: High-ability students require effective educational strategies. This study introduces and evaluates a curriculum enrichment programme aimed at enhancing creativity. The programme is based on a competency framework and was implemented using variations of Project-Based Learning (PBL) strategies. **Method:** A quasi-experimental design compared two interventions using pre-test and post-test groups. The first intervention (N = 38) involved a 12-week PBL unit focused on designing a video game using block-based programming through Scratch. The second intervention (N = 51), also lasting 12 weeks, comprised three separate projects involving vectorial design and programming of an Arduino-based robot. Both interventions used strategies for creative-thinking development. The sample included high-ability students from 8 to 12 years of age. **Results:** Both interventions significantly increased creativity, with no statistical differences between them. This suggests that both types of PBL interventions effectively improved participants' creativity. **Conclusions:** This study suggests that PBL-based curricular enrichment programmes are effective in fostering creativity among high-ability students.

UBUIngenio: programa de enriquecimiento extracurricular para la mejora del pensamiento creativo en alumnado con altas capacidades

PALABRAS CLAVE
Creatividad, alta capacidad, aprendizaje basado en proyectos, pensamiento creativo, programa de enriquecimiento extracurricular

Resumen Antecedentes: Los estudiantes con alta capacidad requieren estrategias educativas efectivas. Este estudio presenta y evalúa un programa de enriquecimiento curricular diseñado para mejorar la creatividad. El programa se basa en un marco de competencias y se implementó utilizando variaciones de estrategias de aprendizaje basado en proyectos (ABP). **Método:** Un diseño cuasi-experimental comparó dos intervenciones utilizando grupos pretest y postest. La primera intervención consistió en una unidad de ABP de 12 semanas centrada en el diseño de un videojuego utilizando programación basada en bloques mediante Scratch. La segunda intervención, también de 12 semanas de duración, consistió en tres proyectos independientes

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de diseño vectorial y programación de un robot basado en Arduino. En ambas intervenciones se utilizaron estrategias para el desarrollo del pensamiento creativo. La muestra incluía estudiantes con altas capacidades de entre 8 y 12 años. **Resultados:** Ambas intervenciones aumentaron significativamente la creatividad, sin diferencias estadísticas entre ellas. Esto sugiere que ambos tipos de intervenciones de ABP mejoraron efectivamente la creatividad de los participantes. **Conclusiones:** Este estudio sugiere que los programas de enriquecimiento curricular basados en ABP son efectivos para fomentar la creatividad entre los estudiantes con altas capacidades.

Creativity is the ability to generate new, valuable or practical ideas or products (Supena et al., 2021), and is considered a vital skill in the 21st century (Lin & Shih, 2022; Wulansari et al., 2019). Gifted students have been found to possess the ability to produce unique ideas (Johnsen, 2021; Sastre-Riba & Pascual-Sufrate, 2013). However, there is limited research on extracurricular initiatives that promote creativity (Pelfrey, 2011). Thus, as Renzulli (2012) emphasised a decade ago, there is a need for tailored programmes.

Given this context, the purpose of this study is to examine the impact of an out-of-school programme called UBUIngenio on the development of creativity in highly able students. This research is relevant and timely, particularly given the need for educational measures for addressing the educational needs of gifted students (Jakubakynov et al., 2021). The promotion of creativity has an important role in advancing society (Johnsen, 2021). Indeed, creativity is considered crucial to prevent negative consequences at both the societal and personal levels (Gómez-Pérez et al., 2014). Therefore, there is a need to address issues related to the role of gifted individuals as agents of change (Sternberg, 2020), which warrants investigation through enrichment programmes that focus on the development of creativity (Hayhoe et al., 2022). The specific research question for this study is as follows:

- How does an extracurricular enrichment programme based on Project-Based Learning impact the creative development of students with high abilities?

Theoretical underpinnings

Creativity is a complex concept encompassing multiple factors (Miner-Romanoff et al., 2019). It goes beyond generating novel ideas and products, playing a crucial role in problem-solving, critical thinking, and finding solutions to various daily life issues (Runco & Pritzker, 2020). In the 1950s, Guilford introduced a definition of creativity that included concrete and measurable indicators. This multidimensional view categorised creativity into five components: fluency, flexibility, originality, elaboration, and divergent thinking (Guilford, 1950). The modern definition of creativity can be traced back to Stein (1953), who characterised it as the generation of new ideas that hold utility. Creativity involves integrating and reinventing existing knowledge and materials to create something novel, emphasising the identification of problems and asking relevant questions (Liu & Schonwetter, 2004). Cognitive flexibility, the ability to adapt and incorporate new ideas into one's knowledge framework, is also a crucial aspect of creativity (Arán Filippetti & Krumm, 2020). In this sense, Cropley (2012) presented three perspectives for understanding creativity: processes, personality, and products/results.

The study of creativity is important due to its potential impact in various fields, including sciences, arts, engineering, and technology (Liu & Schonwetter, 2004). Companies that prioritise innovation require creative individuals for generating valuable ideas (Horkoff et al., 2019). Hence, it is important to promote creativity in education because it is a very prominent feature in diverse fields in the labour market. Thus, innovative teaching methods that promote creativity have become popular recently. In this sense, the literature suggests that socio-constructivist methodologies may foster the development of creativity (Moreno, 2022). For example, Inquiry-Based Learning (IBL) promotes creativity and academic motivation in students (Fatimah, 2018). In the same vein, Project-Based Learning (PBL) is an innovative educational strategy that emphasises creativity and its practical application across a range of disciplines (Jiang & Pang, 2023; Karyawati & Ashadi, 2018).

This student-centred approach promotes self-discovery and self-regulation, allowing students to manage their metacognitive processes and learning. PBL also works well with gifted students (Diffily, 2002; Greeno, 2006). It is often used to foster creativity in primary and secondary school students (Hawari & Noor, 2020; Shatunova et al., 2019). The benefits of PBL have been recognised in the literature (Fitzgerald, 2020). Yuvaci and Daglioglu (2016) and Lew (2012) found that intrinsic and extrinsic motivation positively affect creative thinking. Thus, to motivate gifted students, prevent academic failure, and promote academic success, creativity and educational methods that enhance these skills must be promoted (Jakubakynov et al., 2021; Kim, 2008).

Examining creative processes can serve as a guide for teaching and nurturing creativity. The PBL methodology, as described by Ravitz et al. (2012), follows a similar creative process. It begins with a generative question that presents a problem to be solved or explored, followed by information gathering, critical analysis, planning, and ultimately the development of a project or product (Abidin et al., 2021). Therefore, PBL serves as the theoretical framework for the curriculum enrichment programme investigated in this study.

The UBUIngenio programme

The UBUIngenio plan was designed as an out-of-school curriculum enrichment programme. It is delivered by teachers from the Faculty of Education at the University of Burgos with expertise and background in PBL and education for gifted and talented students. The programme aims to develop communication skills and promote knowledge and positive attitudes toward science while enhancing participants' creativity and developing socio-emotional skills and self-regulation.

In this study, two interventions were designed and evaluated. Both interventions encouraged students to ask questions and approach problems from different perspectives. We incorporated creativity-related techniques including strategies such as SCAMPER (Ozyaprak, 2016; Wu & Wu, 2020). We also used strategies that promote the search for analogies. Such strategies were used to help students think about the materials being used and their role in solving a problem (Candrasekaran, 2014; Serikbayeva & Beisenbayeva, 2020). We draw on literature supporting the use of PBL as a framework for innovative teaching and learning methods. Hence, both interventions were rooted in educational principles such as discovery learning (Campos et al., 2020). This approach encourages the exploration of the connection between different fields of knowledge (Dogan & Pahre, 2019). Both interventions were carried out during after-school hours, each week on Friday afternoon. The interventions have been implemented by a total of 2 different teachers, one for the emotional part and one for the technological part (see description below). Next, we will briefly describe each intervention.

Intervention 1

The first intervention was based on the use of computational programming, through Scratch. It consisted of twelve sessions of two hours each. The first part of each session centred on the development of emotional competencies, due to the relationship between emotional intelligence and the learning process and achievement (Ferragut & Fierro Bardají, 2012; López Zafra & Jiménez Morales, 2009). Students were asked to identify a future problem that could be solved through projects centred on emotional competence. Activities included brainstorming, communicative strategies, visual thinking, and emotional recognition and regulation. The second part centred on the development of technological competencies. Specifically, it consisted of creating a game using Scratch, a software for block-based programming (Su et al., 2022). Students were instructed on how to use the programming blocks and their task was to create a videogame related to the first part of the sessions. The process included planning the videogame, programming it, and refining it by introducing new elements, such as moving objects, sounds, or adding different animations. Regarding the use of Scratch, Kobsiripat (2015) concluded that it had beneficial effects on the promotion of creative skills. Similarly, the intervention of Husna et al. (2019) with Scratch also reported improvements in creativity. Based on these findings, we anticipate that the first intervention will positively impact highly able students' creative thinking abilities.

Intervention 2

The second intervention had similar characteristics to the first one in terms of duration and structure. However, the content of the second part of the sessions varied. Instead of solely designing a videogame with Scratch, the twelve-week intervention consisted of three different projects, each lasting four weeks. The projects involved programming an Arduino robot (Budi et al., (2019), the study of electricity through various materials, and vectorial design, allowing students to learn the basic operations of these tools. In each of the three microprojects, students were required to generate a product or solve a problem individually or in small teams. Specifically, the first project involved constructing a painter robot using recyclable materials. To accomplish this, various activities related to electricity, using blocks, and experiments with *Play-Doh* were undertaken. The second micro-project focused on designing and decorating t-shirts with vinyl. At the beginning of the project, students learned to use the *Inkscape* programme for vectorial design. Subsequently, they used a vinyl-cutting machine to cut out their designs and ironed them onto their t-shirts. The third and final micro-project centred on visual programming using block-based programming (Toma, 2021). In this project, students learned about *Escornabot*, an open-code robot used for learning basic programming concepts. Previous research identified improvements in creativity when teaching with robots (Noh & Lee, 2020) or Arduino programming (Guven et al. 2022). Based on these findings, we anticipated that the second intervention would also positively influence the creative thinking abilities of high ability students.

Method

Design and power analysis

A quasi-experimental, two-group pre-test/post-test design was adopted (Shadish et al., 2002). Key analyses comprised 2 (intervention #1 and #2) x 2 (pre-test-post-test) ANOVA. The required sample size was determined for the interaction between treatment and time and within-group analysis using G*Power 3 (Faul et al., 2007). It was determined that with an alpha = .05 and a power = .80, a moderate effect size (η^2_p = 0.06) might require a minimum of 34 participants (17 per intervention). This study was conducted in accordance with the principles of the Declaration of Helsinki. The procedures used in this study were approved by the bioethics committee of the University of Burgos. Written informed consent for participation, data collection, and publication of the findings was obtained from the parents or legal guardians of the participants.

Participants

A sample for the province of Burgos was prepared using purposive sampling techniques (Cohen et al., 2018). Figure 1 presents the flow diagram of the study. The schools received a letter of invitation specifying the characteristics of the programme and inviting them to inform the families of potential and previously diagnosed highly able students.

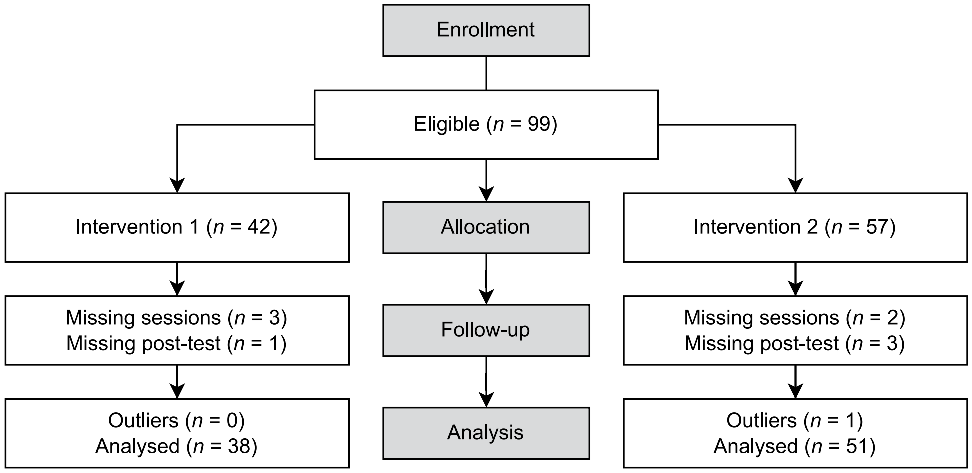

Figure 1. Flow diagram of the study

Participants from different schools, aged 8 to 12 years old were assessed for eligibility. Some of them were already identified as students with high abilities. Participants received no monetary or other types of incentives for participating in the programme. A group of four specialists administered the BADyG test to the students (Yuste et al., 2012). All participating students eligible for the study had Intelligence Quotients (IQs) higher than 119 and were randomly assigned to one of the interventions. Five participants were excluded from the study because they missed more than one intervention session. Additionally, four participants were excluded for missing the post-test. Furthermore, one participant from intervention 2, identified as a univariate outlier during the pre-test, was also excluded. This participant's score was 22, whereas the group mean was 8.26. As a result, the final sample consisted of 38 students (31.6% girls) in Intervention 1 and 51 students (23.5% girls) in Intervention 2.

Instruments

The CREA Creative Intelligence Test (Corbalán et al., 2015), developed and widely applied in the Spanish context, was used to assess the creativity of the participants. The results of numerous investigations have indicated that the CREA test is a valid and reliable test of creativity (for a review, see Corbalán et al., 2015). Based on classical factors of creativity such as divergent thinking, flexibility, fluency, and originality, the CREA test proposes a unified cognitive measure of creativity. To achieve this, participants are instructed to spend four minutes formulating as many questions as possible regarding a visual stimulus (e.g., an image presented on a printed sheet). Afterwards, the questions are evaluated using the quantitative approach explained in Formula 1. This approach assumes that a greater number of questions reflects greater creative development. It is worth mentioning that CREA has three different versions (version A, B, and C), each presenting a different visual stimulus depending on the age of the participants. For the present study, version C was used and scored accordingly. The scores for the CREA-C in the Spanish sample of children between 6 and 11 years of age yield a mean score of 9.36 (*SD* = 5.74; Corbalán et al., 2015).

$$DS = N - O - inQ + EP \quad (1)$$

Note: DS = Direct score; NS = Number of asked questions; O = number of blank spaces or omissions; inQ = number of invalidated questions (repeated, similar, or decontextualised); and EP = Extra points for double or triple questions.

A total of 20% of the questionnaires were evaluated by two raters in order to assess inter-rater reliability using a two-way, mixed-effects, absolute agreement Intraclass Correlation Coefficient, following established guidelines (Koo & Li, 2016). The inter-rater agreement was found to be .947 (95% CI = .88 to .98), which is regarded as excellent.

Data analyses

A Shapiro-Wilk (W) test indicated that the data from intervention 1 had normal distributions both in the pre-test $W(38) = .95$, $p = .09$ and in the post-test $W(38) = .97$, $p = .51$. Likewise, the data from intervention 2 were normally distributed in the pre-test $W(51) = .97$, $p = .14$ and the post-test $W(51) = .96$, $p = .11$. Hence, a 2 x 2 repeated measure ANOVA was conducted to compare scores on the creativity test in the pre-test (pre-intervention) and post-test (post-intervention) and in an independent sample t-test to examine differences in pre-test scores between interventions in terms of age or creativity level. The effect size was determined based on Cohen's (1988) partial eta squared criteria of .01 (small), .06 (moderate), and .14 (large).

Results

Several previous analyses were conducted. An independent sample *t*-test showed no significant differences in the pre-test scores between participants in intervention 1 ($M = 7.87$) and intervention 2 ($M = 8.25$), $t(87) = -.53$, $p = .60$. Additionally, there were no significant differences in participant age between interventions 1 ($M = 9.61$) and 2

(M = 9.67), $t(87) = -0.19$, $p = .85$. Therefore, age and pre-test scores were not used as covariates.

Regarding the main analyses, there was no significant interaction effect between intervention type and time: $F(1, 87) = .32$, $p = .57$ (Figure 2). These results indicate that there was no difference in the change in scores between the two pedagogical conditions over time.

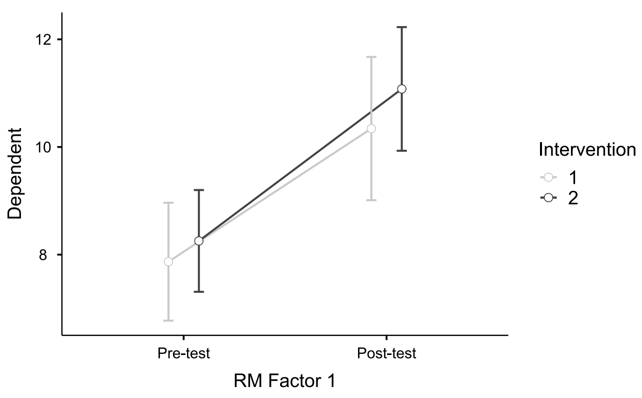

Figure 2. Intervention*Time interaction

An exploration of mean levels indicates that both interventions led to an improvement in creativity (Table 1). To test the statistical significance of this improvement, we conducted follow-up within-group analyses. The results revealed a significant main effect for time, with $F(1, 87) = 73.5$, $p < .01$, partial eta squared = .46. The effect size was large, hence, both groups showed a statistically significant increase in creativity after the intervention (Table 1).

Table 1. Estimated marginal means

				95% Confidence Interval	
Intervention	**Time**	**Mean**	**SE**	**Lower**	**Upper**
1	Pre-test	7.87	0.55	6.77	8.96
	Post-test	10.34	0.67	9.01	11.67
2	Pre-test	8.25	0.48	7.31	9.20
	Post-test	11.08	0.58	9.93	12.23

Finally, the main effect comparing the two types of intervention was not statistically significant, $F(1, 87) = .56$, $p = .46$. This suggests that both interventions were equally effective in improving the creativity of the participants.

Discussion

In the present study, two interventions rooted in PBL were designed and assessed in terms of their effect on the creativity levels of students with high abilities. In the first intervention, the methodology involved the identification of a problem and the creation of a product using Scratch programming software. In the second intervention, three micro-projects regarding the coding of Arduino-based robots and vectorial design printers were implemented. Both interventions lasted twelve weeks.

The results showed that the development of out-of-school, enrichment programmes that use PBL methodologies has a positive effect on creativity, in accordance with extant literature (Folsom, 2005; Kobsiripat, 2015; Makkonen et al., 2021). The novel aspect of our findings is the focus on an under-investigated population, namely, highly able students in primary school education. The results suggested that a PBL model that sets out the solution to a single problem, as in the case of Intervention 1, has the same impact on creativity as an enrichment model based on micro-projects, as conducted in Intervention 2. Taken together, the results from this study suggested that creativity, as measured by a valid and reliable divergent thinking test (Corbalán et al., 2015), can be improved in highly able students either by PBL projects focusing on the use of block-based programming software, such as Scratch, or by using PBL in different micro-projects regarding other technology and information communication resources, such as 3D printers.

Implications

The findings of this investigation have important implications. On the one hand, they provide evidence for the effectiveness of enrichment programmes in fostering creativity in gifted students. The theoretical and methodological approach used in the UBUIngenio programme can be transferred and applied in other similar contexts. Moreover, this study signals the importance of delivering enrichment programmes specifically designed for highly able students (Renzulli & Reis, 2021), while raising the question of whether such programmes may be also effective for non-highly able students. Hence, future research exploring this aspect is warranted. In addition, future studies should explore the impact, if any, of such an enrichment programme on the creativity level of highly able boys and girls from secondary school education.

Furthermore, future research is also needed to determine how this project could be scaled up to be implemented in a formal classroom context, rather than as an extracurricular activity. This would be a laudable effort, in that it will require teacher training in socio-constructivist approaches, including the use of block-based programming resources, as well as techniques for the development of creative thinking.

Limitations and avenues for future studies

Despite the timely and relevant findings reported in this study, this investigation has several limitations. First, we used a measurement instrument that did not allow us to examine the different components of creativity separately (Corbalán et al., 2015). Hence, there is a need for future studies using specific instruments that gather information on the different components of creativity, such as fluency, flexibility, and originality. Likewise, findings should be interpreted considering that there could have been differences in the application of the intervention. While both interventions were implemented by the same two teachers, each teacher may have introduced bias in how the PBL methodology was enacted. Also, given the sample size, there are limitations to the generalisability of the findings across ages, cultures, etc. Finally, since emotional competence was an important aspect of both interventions (Matthews et al., 2018), future studies addressing the impact of the UBUIngenio programme on emotional constructs are encouraged.

Conflict of interest

The authors declare that they have no conflict of interest with respect to the research, authorship and/or publication of this article.

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