VNIVERSITAT DE VALÈNCIA

Facultat de Magisteri
Programa de Doctorado en Didácticas Específicas

TESIS DOCTORAL

DOMINIOS DE LA CREATIVIDAD EN ESTUDIANTES DE EDUCACIÓN SECUNDARIA

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AGRADECIMIENTOS

Azar, destino, casualidad. Estos términos se difuminan entre aquello que controlamos y lo qué no. En ocasiones parece que el Universo conspire a nuestro favor, en otras todo lo contrario. No sé qué fue. Puede que estuviera en el lugar y el momento adecuado. La cuestión es que, durante el año en el que el mundo parecía el escenario de una película medio apocalíptica e infectada, conocí a mi directora de tesis, Yolanda Echegoyen Sanz, que por aquel entonces fue mi tutora de TFM del Máster de Profesorado de Educación Secundaria. Poco después, fui alumna de mi tutor, Joan Josep Solaz Portolés, que me enseñó a mirar la docencia desde otro prisma. No mucho más tarde, Yolanda me presentó al que sería mi segundo director de tesis, Antonio Martín Ezpeleta y, en aquel momento, también tutor de TFM del Máster de Investigación en Didácticas Específicas. Y otra casualidad. En las clases de ese Máster tuve la fortuna de ser alumna del profesor Vicente Sanjosé, que me transmitió la pasión por las cosas bien hechas.

Ahí empezó todo. Pero repito, no sabría explicar qué fue. Supongo que mi naturaleza científica intenta buscar una justificación a ese cúmulo de circunstancias que me llevaron a la realización de esta tesis. Por unas cosas o por otras, tuve la gran oportunidad de sumergirme en la investigación de la creatividad y la enorme suerte de conocer a profesores que me han llevado de la mano durante mis primeros pasos en este camino. Principalmente a vosotros, Yolanda y Antonio: *moltes gràcies per tot, per fer de directors, amics i pares acadèmics, sense vosaltres res hagés estat possible. Seguim i seguirem.*

Aunque no todo han sido profesores. También he tenido la suerte de compartir pupitre con Eva, Patricia, Marta, Mª Amparo y Ade. Con ellas, entre café y café, todo ha sido más ameno.

En casa también he tenido con el apoyo incondicional de mi familia. Mis tíos Pepe y Rosita, han sido mis segundos padres. Mi prima Mariajosé, ha sido más hermana que prima. Mis *peques* caninas, la Cuqui y la Xix, me han alegrado los días. Y como no mis padres, gracias a ellos soy quien soy. Gracias a mi padre, por sembrar las raíces. Gracias a mi madre, por ayudarme a crecer y enseñarme la doble cara de la vida.

Además, durante todo este camino también he contado con otra familia, la que se elige, los de siempre. *Gràcies Àlvar, amic i company a la batalla.* Gracias Viajerin, por tu visión particular del mundo, aunque esta vez haya echado de menos tus notitas. *Gràcies Verin, per haver-me acompanyat des del primer dia de carrera: eres i seràs la meua persona. Gràcies Nèstor, el meu bessó de rebot, per demostrar-me que l'amistat genuïna supera la distancia i el temps.*

En este punto, debo añadir que el camino, como cualquier otro, no siempre ha sido sencillo. Siempre nos podemos encontrar con ciertos tramos más complicados y oscuros. En esos momentos en los que estamos envueltos entre sombras, siempre buscamos luz. *Patri, la meua wel, tu has sigut el meu Sol particular, que ha il·luminat totes les ombres del camí.*

Finalmente, quisiera darle las gracias a Carlos. Lo de encontrarle a él también tuvo que ser azar, destino o casualidad y todo ocurrió como suelen pasar estas cosas. Gracias por contagiarme tu alegría incombustible. *T'estime del dret i del revés.*

No hay más realidad que la que llevamos dentro. Por eso la mayoría de seres humanos vive irrealmente; porque cree que las imágenes son la realidad y no permiten a su propio mundo interior manifestarse. Se puede ser muy feliz así, desde luego. Pero cuando se conoce lo otro, ya no se puede elegir el camino de la mayoría. Sinclair, el camino de la mayoría es fácil, el nuestro difícil.

Caminemos.

Demian - Hermann Hesse

ÍNDICE

Capítulo 1

Resumen

RESUMEN:

La creatividad es considerada una de las competencias clave del siglo XXI por su importancia a la hora de enfrentarse a desafíos personales, académicos o profesionales en un mundo que cambia a gran velocidad. Así lo entiende un organismo internacional como la OCDE, que incluso impulsó en 2022 la evaluación de la creatividad en sus relevantes pruebas PISA; pero también la reciente ley educativa española LOMLOE, que subraya que la creatividad ha de atenderse en todas las materias del currículo. Sin embargo, y dejando de lado esta vez publicaciones sobre propuestas didácticas que identifican la creatividad con la producción artística o la originalidad y no profundizan en su idiosincrasia y carácter multidimensional, no son muchas las investigaciones centradas en investigar la creatividad en la Educación Secundaria en España, una etapa fundamental para canalizar la creatividad de los estudiantes.

Así, el objetivo general de la presente tesis por compendio de artículos es evaluar diferentes dominios creativos en el alumnado de Educación Secundaria (desde 1.º ESO hasta 4.º ESO; con muestras que oscilan entre los 200 y 800 sujetos, repartidos en hasta 8 centros educativos públicos y concertados), así como analizar la autopercepción creativa del profesorado de dicha etapa (un centenar de docentes de hasta 8 centros educativos), que se sabe resulta determinante para su mayor presencia en las aulas. Para ello, se parte de un diseño de investigación exploratorio, cuasi-experimental y mixto, y una selección de instrumentos previamente validados entre los que se encuentran algunos ampliamente utilizados en la investigación educativa sobre creatividad.

Los resultados obtenidos muestran un desempeño moderado-bajo generalizado del alumnado de Educación Secundaria en todas las dimensiones creativas estudiadas (científica, lingüística y general), que correlacionan (de acuerdo con los recientes estudios que definen la creatividad como una macrocompetencia poliédrica) y no

evolucionan de manera significativa a lo largo de los cursos de toda la Educación Secundaria. Por lo que respecta al profesorado, se demuestra que este presenta una autopercepción creativa moderada-alta, aunque cabe destacar que ni la edad, ni los años de experiencia producen cambios en ella, revelando el carácter estático de la formación docente en este particular.

Todos estos resultados evidencian la necesaria atención que requiere la creatividad en el sistema educativo español, según se desarrolla en la discusión y conclusiones, donde se proponen cambios instruccionales y didácticos dirigidos a canalizar de manera sistemática la creatividad en las aulas, superando propuestas de muy modesto alcance en materias concretas; ya que es sabido que para que aflore la creatividad es necesaria una atención constante y transdisciplinar. De todas las propuestas, hay que destacar la importancia de que el profesorado en formación y en ejercicio complete su conocimiento científico de la creatividad, así como que se familiarice con técnicas para atender a la creatividad de sus estudiantes en las aulas.

RESUM:

La creativitat és considerada una de les competències clau del segle XXI per la seua importància a l'hora d'enfrontar-se a desafiaments personals, acadèmics o professionals en un món que canvia a gran velocitat. Així ho entén un organisme internacional com l'OCDE, que fins i tot va impulsar en 2022 l'avaluació de la creativitat en les seues rellevants proves PISA; però també la recent llei educativa espanyola LOMLOE, que subratlla que la creativitat ha d'atendre's en totes les matèries del currículum. No obstant això, i deixant de costat aquesta vegada publicacions sobre propostes didàctiques que identifiquen la creativitat amb la producció artística o l'originalitat i no aprofundeixen en la seua idiosincràsia i caràcter multidimensional, no són moltes les investigacions centrades en

investigar la creativitat en l'Educació Secundària a Espanya, una etapa fonamental per a canalitzar la creativitat dels estudiants.

Així, l'objectiu general de la present tesi per compendi d'articles és avaluar diferents dominis creatius en l'alumnat d'Educació Secundària (des de 1r ESO fins a 4t ESO; amb mostres que oscil·len entre els 200 i 800 subjectes, repartits en fins a 8 centres educatius públics i concertats), així com analitzar l'autopercepció creativa del professorat d'aquesta etapa (un centenar de docents de fins a 8 centres educatius), que es coneix que resulta determinant per a la seua major presència a les aules. Per a això, es parteix d'un disseny d'investigació exploratori, quasi-experimental i mixt, i una selecció d'instruments prèviament validats entre els quals es troben alguns àmpliament utilitzats en la investigació educativa sobre creativitat.

Els resultats obtinguts mostren una desimboltura moderada-baixa generalitzada de l'alumnat d'Educació Secundària en totes les dimensions creatives estudiades (científica, lingüística i general), que correlacionen (d'acord amb els recents estudis que defineixen la creativitat com una macrocompetència polièdrica) i no evolucionen de manera significativa al llarg dels cursos de tota l'Educació Secundària. Pel que respecta al professorat, es demostra que este presenta una autopercepció creativa moderada-alta, encara que cal destacar que ni l'edat, ni els anys d'experiència produeixen canvis en ella, revelant el caràcter estàtic de la formació docent en aquest cas particular.

Tots aquests resultats evidencien la necessària atenció que requereix la creativitat en el sistema educatiu espanyol, segons es desenvolupa en la discussió i conclusions, on es proposen canvis instruccionals i didàctics dirigits a canalitzar de manera sistemàtica la creativitat a les aules, superant propostes de molt modest abast en matèries concretes; ja que és sabut que perquè florisca la creativitat és necessària una atenció constant i transdisciplinar. De totes les propostes, cal destacar la importància que el professorat en formació

i en exercici complete el seu coneixement científic de la creativitat, així com que es familiaritze amb tècniques per a atendre la creativitat dels seus estudiants a les aules.

ABSTRACT:

Creativity is considered one of the key competencies of the 21st century due to its importance in facing personal, academic, or professional challenges in a rapidly changing world. This is understood by international organizations such as the OECD, which even promoted the assessment of creativity in its significant PISA tests in 2022. Similarly, the recent Spanish educational law LOMLOE emphasizes that creativity must be addressed in all curriculum subjects. However, apart from publications on didactic proposals that identify creativity with artistic production or originality and do not delve into its idiosyncrasy and multidimensional nature, there are not many research studies focused on investigating creativity in Secondary Education in Spain, a fundamental stage for channeling students' creativity.

Thus, the general objective of this thesis by compilation of articles is to evaluate different creative domains in Secondary Education students (from 1st ESO to 4th ESO; with samples ranging from 200 to 800 subjects, distributed among up to 8 public and concerted educational centers), as well as to analyze the creative self-perception of teachers in this stage (a hundred teachers from up to 8 educational centers), which is known to be crucial for creative promotion in classrooms. To achieve this, an exploratory, quasi-experimental, and mixed research design is adopted, along with a selection of previously validated instruments, including some widely used in educational research on creativity.

The results obtained show a generally moderate to low performance of Secondary Education students in all studied creative dimensions (scientific, linguistic, and general), which correlate

(according to recent studies defining creativity as a polyhedral macro-competency) and do not evolve significantly throughout the levels of Secondary Education. Regarding teachers, it is found that they have a moderate to high creative self-perceptions, although it is noteworthy that neither age nor years of experience influence on those, revealing the static nature of teacher training in this particular aspect.

All these results highlight the necessary attention that creativity requires in the Spanish educational system, as discussed in the discussion and conclusions, where instructional and didactic changes are proposed aimed at systematically channeling creativity in classrooms, overcoming proposals of very modest scope in specific subjects. It is well known that constant and transdisciplinary attention is necessary for creativity to flourish. Among all the proposals, it is important to emphasize the need for both pre-service and in-service teachers to enhance their scientific knowledge of creativity, as well as to become familiar with techniques to address creativity of their students in the classroom.

Capítulo 2

Introducción

Las aulas de Educación Secundaria muestran una clara contradicción: por un lado, son el escenario idóneo para canalizar la creatividad de un público en una edad especialmente sensible para ello; y por el otro, se observan dificultades u obstáculos que impiden que los estudiantes potencien significativamente su pensamiento creativo. A falta de que los resultados de las Pruebas PISA 2022 arrojen luz sobre las diferencias que se observan en materia de creatividad en función de los sistemas educativos, no se localizan estudios sobre la población española que evidencien una correcta atención al pensamiento creativo. Antes bien, se carga con el prejuicio de que la creatividad es algo relacionado con el arte o en el mejor de los casos las letras, olvidando que es un talento básico para la resolución de problemas, y que estos los hay de muy diversa naturaleza. Resulta curioso que la investigación sobre creatividad, que vivió un crecimiento exponencial en los años 80 del pasado siglo, cuando se desarrollaron y aplicaron las conclusiones de Torrance (1972) o Guilford (1967), no haya terminado de trascender a las prácticas docentes en general, y que la omnipresencia de la palabra *creatividad* en publicaciones de carácter educativo evidencie una falta de rigor en su conceptualización y gran desconocimiento.

La OCDE (Vincent-Lancrin et al., 2019) viene insistiendo en todo ello, divulgando una definición de la creatividad como competencia que sirve para resolver problemas de forma original y útil o funcional, es decir, que la creatividad lejos de ser un adorno es una capacidad fundamental para la formación de las personas, por mucho que esta esté condicionada en un porcentaje elevado a la inteligencia (Ruíz et al., 2014; López y Navarro, 2010; Corbalán et al., 2003). Según se tendrá ocasión de comprobar, no puede afirmarse que la creatividad que los estudiantes poseen termine de despertarse o canalizarse en las aulas. Esto resulta especialmente preocupante cuando se piensa en la trascendencia de la misma para su éxito

personal, académico y profesional (Kaufman y Sternberg, 2019; Corbalán et al., 2003).

Sobre todo ello versa esta tesis doctoral por compendio de artículos, que parte de los últimos estudios sobre el carácter multidimensional de la creatividad (Elisondo, 2021; Kapoor et al., 2021; Baer, 2015; Boccia et al., 2015) para diseñar una investigación que atienda transversal y transdisciplinarmente a la evaluación de la creatividad en las aulas de Educación Secundaria en España, sin olvidar el papel que en ello juega el profesorado en activo. No se conocen estudios para esta población española que enfoquen este carácter multidimensional, pero sí cabe traer a colación estudios recientes impulsados desde grupos interdisciplinares con una presencia muy importante de las Didácticas Específicas (Martín-Ezpeleta et al., 2024; Martín-Ezpeleta et al., 2022; Alfonso-Benlliure y Mínguez-López; 2022; Vicente-Yagüe et al., 2022; Echegoyen-Sanz y Martín-Ezpeleta, 2021), contribuyendo a dibujar un panorama de la creatividad en el sistema educativo español no muy positivo. Completa todo ello la atención al caso particular de las asignaturas denominadas STEM y la importancia que la creatividad tiene en ellas para la optimización de los procesos de enseñanza-aprendizaje, alineándose con claves teórico-metodológicas refrendadas por la Didáctica de las Ciencias Experimentales (Izquierdo-Sanchis et al., 2023; Gómez-Ferragud et a., 2016; Solaz-Portolés y Sanjosé, 2008).

Es bien sabido que la creatividad proporciona al alumnado herramientas para desenvolverse en un mundo, que no solo es versátil y está en constante cambio, sino que ahora también es virtual y artificial. Al brindar acceso a diversas perspectivas, conocimientos y experiencias, la educación desempeña un papel crucial en el desarrollo de la creatividad junto con otras habilidades esenciales, como la comunicación, el trabajo en equipo y la adaptabilidad (Vicente-Yagüe-Jara et al., 2023; Bates et al., 2020; Chen et al., 2020).

No ha de extrañar, pues, que la reciente ley LOMLOE disponga que: "la creatividad se trabajará en todas las materias" (2020, artículo 24, pág. 122891). Parece claro que el debate impulsado por la OCDE (2023) está trascendiendo a la esfera nacional, pero lo cierto es que en las anteriores leyes educativas españolas ya se hacía referencia explícita a la creatividad (LOMCE, 2013; LOE, 2006), por mucho que no pueda concluirse que esta haya formado parte de los objetivos educativos principales. Cuando se publiquen los resultados de las Pruebas PISA 2022 (OCDE, 2023) y los informes consuetudinarios habrá ocasión de triangular la situación de España con otros países, pero también los resultados que en esta tesis se muestran, pues, además de evaluar a estudiantes de 15 años como hacen las Pruebas PISA, aquí se tiene acceso a una radiografía de toda la Educación Secundaria, donde ya anticipamos que destaca un resultado negativo por encima de cualquier otro: no se observa evolución de la creatividad de los estudiantes ateniendo a la variable de la edad, lo cual es muy sintomático de que no se está estimulando correctamente el pensamiento creativo en las aulas, pues la adolescencia es una etapa de extraordinario desarrollo intelectual.

Respecto a la estructura del presente documento, este sigue las directrices establecidas por la Escuela de Doctorado de la Universitat de València para el caso de la modalidad de las tesis por compendio de artículos (Requisitos de tesis por compendio de artículos, aprobados el 26 de octubre del 2021: CCAPD, 2021). Por ello, se compilan en el Anexo I cuatro artículos publicados/aceptados que vertebran la investigación desarrollada, además de otro artículo en proceso de revisión (Anexo II), que enriquece y complementa esta tesis. Cabe mencionar que estos artículos se encuentran todos en revistas indexadas en los índices internacionales JCR/WoS y/o SJR/Scopus. Sin embargo, se debe puntualizar que el orden de aparición de los mencionados artículos en este trabajo no corresponde con las fechas de aceptación/publicación de los mismos;

sino con el orden en que fueron concebidas las investigaciones y la secuencia lógica de su desarrollo. Además, este trabajo incluye una breve compilación de información clave, tal y como dictan los requerimientos, para la contextualización de los artículos que forman el compendio. Esta información se presenta en los siguientes epígrafes a esta introducción: marco teórico, objetivos, aspectos metodológicos, principales resultados y conclusiones, limitaciones, prospectiva e implicaciones educativas.

A continuación, se procede a exponer de manera resumida el contenido de los cuatro artículos principales, así como una sucinta descripción del artículo complementario en proceso de evaluación. Para los cuatro primeros, también se presentan datos técnicos en referencia al impacto e indexación de la revista, aparte de una descripción general de la contribución y su aportación científica.

2.1. PRESENTACIÓN DE LOS ARTÍCULOS DEL COMPENDIO

Como se ha mencionado anteriormente, esta tesis doctoral se compone de cuatro artículos principales (reproducidos en el Anexo I). Cada uno de ellos posee su enfoque particular y sus objetivos específicos, pero todos ellos están en línea con el objetivo general de este trabajo. Así pues, como se describirá posteriormente, los tres primeros artículos se centran en determinados dominios de la creatividad y su evaluación en estudiantes de Educación Secundaria, mientras que el último está focalizado en la autopercepción creativa del profesorado de dicha etapa. En la descripción de cada uno de ellos, se presenta un análisis en profundidad de los datos recopilados, discutiendo sus perspectivas y limitaciones en clave educativa. En este punto cabe matizar que la elección de las revistas para la publicación de estos estudios se basó, por un lado, en la consonancia de la investigación con las líneas editoriales de revistas prestigiosas;

y por otro lado, en los requerimientos propios del Programa de Doctorado en Didácticas Específicas.

2.1.1. PRIMER ARTÍCULO

- **Autores**: Isabel Pont Niclòs, Antonio Martín Ezpeleta y Yolanda Echegoyen Sanz
- **Título**: The turning point: scientific creativity assessment and its relationship with other creative domains in first year secondary students
- **Referencia**: Pont-Niclòs, I., Martín-Ezpeleta, A., & Echegoyen-Sanz, Y. (2023). The turning point: scientific creativity assessment and its relationship with other creative domains in first year secondary students. *Jurnal Pendidikan IPA Indonesia*, 12, 221-231. http://dx.doi.org/10.15294/jpii.v12i2.42835

- **Indexación:**

Índice de impacto	Cuartil	Posición de la revista (total)	Categoría	Índice
0.46 (SJR) año 2021	Q2	574 (1440) año 2021	Social Sciences: Education	Scopus (SJR)

- **Estado del artículo**: publicado.
- **Descripción general y resumida**:

En este artículo se abordó la evaluación de la creatividad en estudiantes de primer año en Educación Secundaria. Este nivel de la etapa es crucial, ya que marca la transición de la Educación Primaria a la Secundaria. Esa transición está caracterizada por cambios en las metodologías educativas, incluida la introducción de disciplinas científicas y una modificación general de las metodologías docentes. Concretamente en el trabajo se proponen tareas de aula que sirven para evaluar la creatividad relacionadas con la creatividad científica

y la creatividad lingüística, junto con una actividad asociada a un enfoque más general de la creatividad.

Para ello, se partió de tres instrumentos validados, cada uno de los cuales se focalizaban en uno de los mencionados dominios creativos. Por un lado, la creatividad científica se evaluó mediante una tarea de formulación de problemas científicos desarrollada por Hu et al. (2010). Por otro lado, la creatividad lingüística se midió en base a una tarea de generación de metáforas, diseñada por Kasirer y Mashal (2018). Finalmente, la creatividad general se abordó mediante el cuestionario CREA (Corbalán et al., 2003), que consistía en la generación de preguntas relacionadas con una imagen. Los aspectos metodológicos se encuentran descritos en mayor profundidad en el Capítulo 5.

Concretamente, en este estudio participaron un total de 226 estudiantes de primero de Educación Secundaria, adscritos a tres centros educativos diferentes, entre los cuales existía una distribución homogénea de géneros (53% femenino y 47% masculino) y se tenía una media de edad típica, dentro del mencionado nivel educativo (media: 12.2; desviación estándar: 0.5). El análisis estadístico de los resultados se realizó utilizando el software SPSS. En primer lugar, se calculó la media y la desviación estándar de todas las dimensiones evaluadas. La prueba de Kolmogorov-Smirnov reveló la no normalidad de los datos. Por ello, las diferencias de género se exploraron mediante la prueba U de Mann-Whitney. En todas las pruebas el nivel de significancia fue de 0.05. El tamaño del efecto se calculó utilizando la fórmula de Field (2018) para muestras no paramétricas y fue interpretado mediante la clasificación de Cohen para Ciencias Sociales (1988). Finalmente, la correlación entre los dominios de creatividad científica, lingüística y general fue analizada con el cálculo de los coeficientes de correlación de Pearson.

De manera breve, los resultados obtenidos pusieron de manifiesto una deficiencia en la creatividad científica, lingüística y

general entre los estudiantes del primer nivel de la etapa de Educación Secundaria. Además, las evidencias recopiladas respaldan la naturaleza multicomponente de la creatividad e identifican diferencias de género en su desempeño. En el Capítulo 6, puede encontrarse un análisis más detallado de estos resultados. Sin embargo, cabe mencionar que en este artículo únicamente se realiza la evaluación del primer nivel de Educación Secundaria, teniendo además otras limitaciones asociadas a los instrumentos validados utilizados y el muestreo por conveniencia.

2.1.2. SEGUNDO ARTÍCULO

- **Autores**: Isabel Pont Niclòs, Yolanda Echegoyen Sanz y Antonio Martín Ezpeleta
- **Título**: Assessing the linguistic creativity domain of last-year compulsory secondary school students.
- **Referencia**: Pont-Niclòs, I., Echegoyen-Sanz, Y., & Martín-Ezpeleta A. (2024). Assessing the linguistic creativity domain of last-year compulsory secondary school students. *Education Sciences*, 14, 153. https://doi.org/10.3390/educsci14020153
- **Indexación**:

Índice de impacto	Cuartil	Posición de la revista (total)	Categoría	Índice
0.61 (SJR) año 2022	Q2	326 (1469) año 2022	Social Sciences: Education	Scopus (SJR)

- **Estado del artículo**: publicado.
- **Descripción general y resumida**:

Este segundo artículo se centra en la creatividad lingüística. Concretamente, se exploran los vínculos entre la producción creativa de metáforas y dos tareas de pensamiento divergente: una de proponer usos alternativos y otra de denominar de palabras no

relacionadas. Con ello, se pretende sumar evidencias acerca del carácter multifacético de la creatividad lingüística, así como obtener información sobre los diferentes mecanismos y correlaciones subyacentes entre redes semánticas y procesos cognitivos tanto divergentes, como convergentes. En esta ocasión, el foco se pone en el último nivel de la etapa de Educación Secundaria; ya que las competencias lingüísticas de sus estudiantes pueden estar suficientemente maduras para afrontar las tareas creativas lingüísticas propuestas. Además, sus habilidades creativas pueden arrojar luz sobre la idoneidad del sistema educativo español para desarrollarlas.

Particularmente, participaron un total de 454 estudiantes españoles de cuarto curso de Educación Secundaria Obligatoria, adscritos a ocho centros educativos diferentes, tanto de zonas rurales, como urbanas. Hubo homogeneidad de género entre los participantes (51% femenino y 49% masculino) y su edad oscilaba alrededor de la media típica para ese nivel (media: 15.3; desviación estándar: 0.6).

Como en el caso del artículo descrito anteriormente, la creatividad lingüística se evaluó mediante el planteamiento de tareas de aula, las cuales estaban basadas en cuestionarios previamente publicados y validados. La primera tarea creativa (denominar palabras no relacionadas) se correspondía con la evaluación de la distancia semántica desarrollada por Olson et al. (2021). Esta consistía en nombrar diez palabras que fueran lo más diferentes posible entre sí, en todos los significados y usos de las palabras (por ejemplo, canción y hormiga). Con ello, se evalúa el pensamiento divergente a través de la distancia semántica entre las palabras seleccionadas. La segunda tarea creativa se focalizaba en la capacidad de generar metáforas y se evaluó mediante un instrumento desarrollado por Levorato y Cacciari (2002) y posteriormente adaptado por Kasirer y Mashal (2018). Se pidió a los estudiantes que idearan diez metáforas,

para describir un total de diez elementos referidos a un sentimiento o emoción particular (por ejemplo, felicidad, tristeza, euforia o frustración). A diferencia de la tarea anterior, además del pensamiento divergente, en este caso también se activan procesos relacionados con el pensamiento convergente y otros elementos metalingüísticos. Finalmente, la tercera tarea creativa utilizada fue extraída del test PIC-J (Artola et al., 2008), la cual consta con elevada validez y fiabilidad con estudiantes españoles. Para su realización, se pidió a los estudiantes que idearan usos alternativos para un tubo de goma. Esta última prueba evalúa, principalmente, las habilidades de pensamiento divergente para producir múltiples ideas y asociaciones. La descripción detallada de la metodología aplicada se encuentra en el Capítulo 5.

El análisis estadístico se realizó con el software SPSS. En primer lugar, se calcularon la media y la desviación estándar para cada una de las dimensiones de creatividad estudiadas. En segundo lugar, se utilizó la prueba de Kolmogorov-Smirnov para evaluar la normalidad de las distribuciones. Luego, las diferencias de género se investigaron utilizando la prueba t de Student para muestras independientes (variables normalmente distribuidas) o la prueba U de Mann-Whitney (variables no distribuidas normalmente). Finalmente, la correlación entre variables se analizó mediante la Correlación de Pearson. En todas las pruebas el nivel de significancia fue de 0.05. La magnitud del tamaño del efecto se evaluó de manera análoga a la mencionada en el artículo anterior.

El análisis de los datos reveló que los estudiantes muestran un desempeño creativo moderado en la tarea de denominar palabras no relacionadas y en la tarea de usos alternativos, mientras que su puntuación en la prueba de generación de metáforas era notablemente baja. En cuanto a la influencia del género, se obtuvieron diferencias estadísticamente significativas en las tareas de generación de metáforas y usos alternativos, obteniendo las alumnas

puntuaciones más elevadas en ambos casos. Por otro lado, las dos tareas más estrechamente relacionadas con el pensamiento divergente (denominar palabras no relacionadas y proponer usos alternativos) no presentaron correlación entre ellas, mientras que la tarea que suponía procesos creativos más amplios (tarea de generación de metáforas), sí se correlacionaba con las otras dos. Estos hallazgos señalan los procesos distintos pero interconectados que subyacen a la creatividad. Todo ello se discute con mayor detalle en el Capítulo 6.

2.1.3. TERCER ARTÍCULO

- **Autores**: Isabel Pont Niclòs, Antonio Martín Ezpeleta y Yolanda Echegoyen Sanz
- **Título**: Scientific and linguistic creative domains in Secondary Education.
- **Referencia**: Pont-Niclòs, I., Martín-Ezpeleta A., & Echegoyen-Sanz, Y. (2024). Scientific and linguistic creative domains in Secondary Education. A case study in Spain. *European Journal of Contemporary Education*, X, X-X.
- **Indexación**:

Índice de impacto	Cuartil	Posición de la revista (total)	Categoría	Índice
0.392 año 2022	Q2 (SJR)	401(1469) año 2022	Social Sciences: Education	Scopus (SJR)

- **Estado del artículo**: aceptado (se adjunta carta de aceptación).
- **Descripción general y resumida**:

En este tercer artículo del compendio se exploran simultáneamente tanto el dominio científico como el lingüístico de la creatividad. Además, se amplía el espectro de estudio, abarcando todos los niveles de la etapa obligatoria de Educación Secundaria.

Este enfoque posibilita obtener una idea del desempeño de los estudiantes en diferentes dominios de la creatividad, además de su posible desarrollo durante la etapa.

Particularmente, el estudio presenta un diseño de investigación exploratorio, transversal y cuantitativo, en el cual participaron 223 estudiantes de los cuatro niveles de la etapa de Educación Secundaria Obligatoria. La distribución del género del alumnado fue homogénea (52% femenino y 48% masculino), así como fue su distribución en los diferentes niveles de la etapa educativa. En cuanto a los instrumentos de investigación utilizados, para evaluar la creatividad científica se utilizaron las tareas de formulación de problemas científicos desarrolladas por Hu et al. (2010), pudiendo así abarcar los dominios cotidiano (DSC) y específico (SSC), de la creatividad científica. Por otro lado, la creatividad lingüística se estudió a partir de la producción de metáforas, utilizando el instrumento diseñado por Kasirer y Mashal (2018).

Todos los datos recogidos fueron tratados de forma anónima (según las indicaciones del Comité de Ética de la Universitat de València) y se utilizó el programa SPSS para realizar los cálculos estadísticos pertinentes. Tras determinar la normalidad de las distribuciones mediante la prueba de Kolmogorov-Smirnov, se realizó un análisis estadístico inferencial para valorar la existencia de diferencias significativas entre las variables. Así, para la comparación entre géneros se utilizó la prueba U de Mann-Whitney para distribuciones no normales y la prueba t de Student para variables con distribuciones normales. Para realizar la comparación por nivel educativo, se utilizó la prueba de Kruskal-Wallis para variables no normales y la prueba ANOVA para variables normales. Finalmente, para estudiar la correlación entre los diferentes dominios de la creatividad estudiados, se utilizó la correlación de Pearson. En todos los casos el nivel de significación estadística se fijó en 0.05 y los

tamaños de los efectos se evaluaron de manera análoga a la descrita en los artículos anteriores.

Los resultados nuevamente se correspondían con los reportados anteriormente, mostrando un desarrollo de la creatividad de moderado a bajo en todos los dominios de creatividad estudiados, aunque particularmente deficiente en el caso de la creación de metáforas. También de manera análoga se detectaron diferencias estadísticamente significativas según el género, siendo las alumnas las que mostraban mayor desempeño creativo (Nakano et al., 2021).

Un aspecto que cabe destacar de esta contribución es la identificación de una correlación positiva entre la creatividad científica y la lingüística, en conjunción con una correlación aún más considerable entre ambos (micro)dominios de la creatividad científica (cotidiano, DSC y específico, SSC). Así pues, se puede concluir que el alumnado creativo lo es en todos los dominios, aunque según su perfil (conocimiento específico, intereses, motivaciones y autoconcepto) mostrará un mayor desempeño en un particular dominio creativo (Prosekov et al., 2022). Finalmente, el otro aspecto que merece la pena subrayarse de este estudio es el limitado fomento de la creatividad a lo largo de la etapa de Educación Secundaria Obligatoria. Esto suma evidencias acerca del papel subsidiario y relegado que ostenta la creatividad en la mencionada etapa educativa. Queda mucho camino que recorrer entre lo ordinario y lo extraordinario. Un camino que comienza con la evaluación de la creatividad en el sistema educativo español, tanto desde la perspectiva del alumnado como del profesorado, y sigue hacia la promoción de la creatividad en las aulas, mediante el diseño de adecuados programas, intervenciones y planes de acción.

2.1.4. CUARTO ARTÍCULO

- **Autores**: Isabel Pont Niclòs, Yolanda Echegoyen Sanz y Antonio Martín Ezpeleta
- **Título**: Creative self-perception of Spanish secondary teachers.
- **Referencia**: Pont-Niclòs, I., Echegoyen-Sanz, Y., & Martín-Ezpeleta A. (2024). Creative self-perception of Spanish secondary teachers. *Journal of Education, Culture and Society*, X, X-X.
- **Indexación**:

Índice de impacto	Cuartil	Posición de la revista (total)	Categoría	Índice
1.0 (CiteScore) año 2022	Q3	1013 (1469) año 2022	Social Sciences: Education	Scopus

- **Estado del artículo**: aceptado (se adjunta carta de aceptación).
- **Descripción general y resumida**:

Es sabido que hay varios factores que influyen en el desarrollo del potencial creativo en las escuelas, desde las experiencias individuales, los conocimientos previos y las preferencias personales hasta las condiciones ambientales (Glaveanu et al., 2019; Beghetto y Kaufman, 2014). Sin embargo, entre todos estos factores, los investigadores se inclinan por considerar que los docentes tienen una influencia notable en la promoción u obstaculización de la creatividad de los estudiantes (Bereczki y Karpati, 2018). Tanto es así que diversos autores (Chan y Yuen, 2014; Yates y Twigg, 2017) incluso afirman que los docentes deben haber desarrollado previamente su propia creatividad para poder desarrollar la creatividad de los estudiantes.

Por todo ello, este cuarto artículo de la tesis se centra en evaluar la autopercepción creativa del profesorado de Educación Secundaria, con el propósito de obtener una perspectiva más amplia acerca del

papel que ostenta la creatividad a las aulas de Secundaria españolas. Además, también se analiza la influencia del género, la edad, los años de experiencia y el área de docencia.

Los participantes corresponden a profesorado de Educación Secundaria adscritos a ocho centros educativos diferentes y en ejercicio en el momento del estudio, haciendo un total de 100 docentes especializados en diferentes áreas: Artes (N=3), Lengua y Literatura (N=38), Matemáticas y Tecnología (N=18), Música (N=6), Ciencias Naturales (N=12), Educación Física (N=6) y Ciencias Sociales (N=17). La edad de los docentes osciló entre 25 y 60 años (media: 45.4; desviación estándar: 9.4). Cabe destacar que la muestra global posee homogeneidad en la distribución de género (48% femenino y 52% masculino).

Como instrumento de evaluación de la autopercepción creativa se utilizó el cuestionario conocido como el K-DOCS (Kaufman, 2012), el cual se encuentra descrito con mayor detalle en el Capítulo 5. El cuestionario incluye 50 ítems relacionados con 5 dominios de creatividad diferentes: Cotidiano, 11 ítems; Académico, 11 ítems; Actuación, 10 ítems; Científico/Mecánico, 9 ítems; y Artístico, 9 ítems. En el proceso de recogida de datos, se pidió al profesorado que se compararan con iguales (en términos de edad y experiencias) para evaluar su propio desempeño en tareas creativas.

El análisis estadístico se realizó mediante el software SPSS. En concreto, se calculó la media y la desviación estándar para cada dimensión del cuestionario. La distribución de normalidad de los datos se comprobó mediante la prueba de Kolmogorov-Smirnov. Para dilucidar la existencia de diferencias significativas entre géneros se aplicaron las pruebas t de Student o U de Mann-Whitney, para distribuciones normales y no normales, respectivamente. En cuanto al análisis de diferencias significativas según grupo de edad, años de experiencia y área de docencia, se utilizó ANOVA (distribuciones normales) o la prueba de Kruskal-Wallis (distribuciones no

normales). Además, se llevaron a cabo pruebas *post hoc* según fue necesario para explorar más a fondo esas diferencias entre grupos de docentes. En todas las pruebas el nivel de significancia fue de 0.05. La magnitud de los tamaños de efecto se evaluó de manera análoga a la descrita en los artículos anteriores.

El análisis de los datos recopilados reveló que el profesorado de Educación Secundaria posee un nivel de autopercepción creativa de moderado a alto, en los diferentes dominios estudiados. En particular, las puntuaciones más altas se encontraron en el dominio Cotidiano, seguido de los dominios Artístico y Académico. Sin embargo, los dominios Actuación y Científico/Mecánico presentaron perfiles de autopercepción de creatividad más bajos, siendo este último el que presentó valores más reducidos.

Al analizar las diferencias de género entre las profesoras y profesores, se obtuvieron diferencias estadísticamente significativas, con un tamaño del efecto elevado, en el dominio Científico/Mecánico. Respecto a la influencia de la edad y los años de experiencia del profesorado de Educación Secundaria, el análisis de los datos no mostró diferencias estadísticamente significativas, apuntando hacia el carácter estático de la formación durante la carrera docente. Respecto a la dependencia del área de especialización y la autopercepción creativa, se observó una ligera correlación, la cual puede estar asociada el propio autoconcepto y aspectos emocionales/motivacionales (Elisondo et al., 2022; Perera et al., 2018). Cabe resaltar que la muestra, aunque suficiente, podría ampliarse para incluir diferentes niveles educativos como Educación Infantil o Educación Primaria, y ser más deslocalizada. En cualquier caso, el cuarto artículo del compendio contribuye a proporcionar más información sobre el papel del profesorado en la presencia de la creatividad en las aulas.

2.2. PRESENTACIÓN DEL ARTÍCULO COMPLEMENTARIO

Como se ha mencionado anteriormente, se presenta en el Anexo II un artículo más, el cual se encuentra en proceso de revisión a fecha de depósito de esta tesis. Este artículo se encuentra totalmente alineado con el objetivo general de la tesis, por lo que se procede a incluir una breve descripción de este, ya que no solo complementa los estudios del compendio, sino que los amplía.

2.2.1. RESUMEN DEL ARTÍCULO COMPLEMENTARIO

En este estudio complementario se exploran las dimensiones específica y cotidiana de la creatividad científica, en estudiantes de todos los niveles de la Educación Secundaria (N = 780), así como su relación con las aptitudes hacia la ciencia y las vocaciones profesionales relacionadas con las áreas STEM (del inglés: *Science, Technology, Engineering and Mathematics*). Los resultados muestran una reducida creatividad científica, en consonancia con los resultados del compendio de la tesis, aparte de percepciones moderadamente precisas y positivas sobre cómo funciona la ciencia y sus implicaciones individuales y colectivas. Sin embargo, destaca la participación limitada del alumnado en actividades de divulgación científica y una baja expectativa de seguir carreras relacionadas con las áreas STEM. En cuanto a las diferencias entre géneros, estas se detectaron tanto en la creatividad científica, como en las percepciones y expectativas profesionales relacionadas con la ciencia, siendo las alumnas las que obtenían puntuaciones más elevadas. Contrariamente, no se encontraron diferencias en la creatividad científica entre los niveles de Educación Secundaria, aunque se observó una mejora en las percepciones sobre la ciencia a medida que los estudiantes progresaban en el sistema educativo. Lamentablemente, también se detectó una disminución en la vocación profesional científica en niveles más altos. Estos resultados

vuelven a destacar la importancia de fomentar la creatividad científica puesto que esta puede promover el interés en seguir la formación o perseguir carreras STEM, más allá de los límites obligatorios de la educación.

Capítulo 3

Marco Teórico

3.1. LA CREATIVIDAD EN LA EDUCACIÓN

Como se ha mencionado en la introducción, no existe una única definición de la creatividad, pero la mayoría de ellas presentan dos nexos comunes: novedad y utilidad (Stein, 1953). El primero de estos conceptos está asociado a la originalidad, mientras que el segundo se refiere a la aplicabilidad a un contexto concreto. Además, hay un claro consenso en este campo de investigación respecto de la naturaleza multicomponencial de la creatividad (Barbot et al., 2019). Por este motivo, existen diversas propuestas, teóricas y empíricas, basadas en diferentes perspectivas psicológicas que tratan de analizar esa naturaleza poliédrica.

Por un lado, las características de la personalidad de los individuos creativos han sido estudiadas mediante determinados instrumentos de investigación, como cuestionarios de personalidad general o repertorios con factores específicos relacionados con la creatividad (Amabile, 2012; Corbalán y Limiñana, 2010; Batey y Furnham, 2006). Cabe destacar que la mayoría de estas investigaciones han constatado la existencia de determinados atributos de la personalidad estrechamente relacionados con el potencial creativo, como la apertura a nuevas experiencias, así como el interés por descubrir y experimentar (Romo et al., 2017). Por otro lado, los mecanismos implicados en la producción creativa han estado también ampliamente estudiados en la bibliografía especializada.

Otro de los debates más intensos tiene que ver con la explicación de la naturaleza y procesos que intervienen en la creatividad. Así, por ejemplo, se encuentra el modelo conocido como "las 4 P" de Rhodes (1961), que, aunque ha sido superado, sigue resultando ilustrativo. Según este modelo se puede cercar la creatividad de acuerdo a cuatro aspectos: la persona, es decir, el individuo que realiza la tarea creativa; el proceso, asociado al

desarrollo de esa tarea; el producto, centrado únicamente el artefacto creativo final; y la prensa, relacionado con el entorno en el cual se desarrolla el estudio.

Más completo es el reciente modelo de las "4 C" (Kaufman y Beghetto, 2009) sobre los procesos que intervienen en la creación. Este establece cuatro niveles de magnitud creativa decreciente. El primero de ellos es *Big-C*, el cual se encuentra relacionado con la desenvoltura creativa a la altura de genio incuestionable y que, además, tiene un impacto claro en la sociedad, como, por ejemplo, los poemas de Antonio Machado o las canciones de Joaquín Sabina. El segundo nivel es *Pro-c*, que tiene un tinte más profesional y, por tanto, es característico de expresiones creativas de expertos con influencia en un contexto específico, por ejemplo, una estrategia de márquetin en las redes sociales. En tercera posición se encuentra el nivel *Little-c*, que ni es pequeño ni simple, sino que es accesible a la mayoría de personas a través de la práctica y se desarrolla en contextos cotidianos, como puede ser cocinar y emplatar una cena poco habitual o hacer una fotografía particular durante un viaje. Finalmente, se tienen en cuenta las expresiones creativas catalogadas como *Mini-c*, asociadas íntimamente con el proceso de aprendizaje.

En este último nivel es donde se encuentran precisamente todos los intentos y mecanismos que los estudiantes ponen en marcha cuando se enfrentan a una nueva tarea, que, aun no siendo una obra maestra que marque la historia de la humanidad, constituyen una pequeña-gran revolución en la (re)construcción de su propio conocimiento. En definitiva, si se analiza el modelo de "las 4 C" en clave educativa, se puede concluir que este constituye una amalgama de todas las manifestaciones creativas posibles que se pueden producir durante el proceso de aprendizaje.

Teniendo en cuenta todo lo mencionado, la creatividad y la educación son procesos que se nutren el uno del otro y que se encuentran reforzados por la interacción entre estudiantes y su

entorno, tanto académico como sociocultural (Lemmetty et al., 2021). Por tanto, la escuela se puede considerar como el campo de entrenamiento idóneo para desarrollar las competencias creativas; ya que proporciona acceso a experiencias, conocimientos, opiniones y perspectivas variadas, así como la posibilidad de potenciar habilidades de adaptabilidad, comunicación y cooperación (Vincent-Lancrin et al., 2019). Todo esto es imprescindible en un mundo cada vez más versátil e interconectado, que presenta nuevos desafíos sin precedentes. En este mundo que es el siglo XXI, la creatividad merece un papel (co-)protagonista en la formación de los individuos, dotándolos de las herramientas necesarias para ir más allá de los límites tradicionales (Taguma et al., 2018).

Para terminar, no puede dejarse de mencionar tratando de los cambios del siglo XXI un asunto de gran actualidad y enorme potencial, como es la relación que se establece en los contextos educativos entre la creatividad y la inteligencia artificial (IA). Internet, los teléfonos móviles (si es que hay de otros tipos), las redes sociales y muchos otros productos y dispositivos digitales desempeñan un papel fundamental en la vida del siglo XXI (Terzian, 2019). Pero la información generada por esta tecnología es superior a la se puede asimilar, es decir, a la que se puede convertir en conocimiento.

En este contexto, las herramientas de Inteligencia Artificial (IA) pueden resultar grandes aliadas, pues ya realizan ciertas funciones cognitivas humanas (Miller, 2019). De hecho, la preocupación aumentó rápidamente cuando un algoritmo de IA, concretamente el *AlphaGo,* superó a jugadores profesionales de un juego asiático ancestral (Silver et al., 2016). Lógicamente, esas preocupaciones no tenían nada que ver con la derrota y el espíritu competitivo humano, sino con el remplazamiento de la inteligencia humana y sus potenciales implicaciones en multitud de esferas (Spector y Ma, 2019; Rampersad, 2020), como en la de Educación (Chen et al., 2022;

Lameras y Arnab, 2021). A pesar de las nuevas posibilidades que la IA ofrece al aprendizaje, la enseñanza y los procesos de evaluación, así como a la realización de tareas administrativas, también supone todo un abanico de consideraciones éticas y desafíos sin precedentes (Zawacki-Richter, 2019). En este contexto, la investigación que se ocupa de la aplicación de la IA en la Educación se centra fundamentalmente a las conocidas como competencias del siglo XXI (Xia et al., 2022), las cuales se consideran esenciales para desenvolverse en este nuevo paradigma.

De entre todas esas competencias, la creatividad ha sido puesta en el punto de mira, no solo en relación con las herramientas IA (Huang, 2018); sino como una habilidad humana clave que combina procesos intra- e interpsicológicos que influyen en los individuos personal y colectivamente y que, además, se puede desarrollar según una adecuada compilación de interacciones y actividades. Pero no todo son malas noticias. Recientemente, un estudio ha constatado que, a pesar de la heterogeneidad del potencial creativo de las personas, las ideas creativas humanas áureas exceden, o al menos son comparables, a aquellas proporcionadas por *chatbots* de IA generativa (Koivisto y Grassini, 2023). Se trata de un campo de investigación en ciernes, que, eso sí, empieza a demostrar resultados suficientemente estimulantes (Vicente-Yagüe-Jara et al., 2023) como para perseverar en la misma.

3.2. Los dominios creativos y su evaluación

Precisamente, ese papel (co-)protagonista de la creatividad en la Educación al que se hacía referencia en el epígrafe anterior ha posibilitado explorar multitud de líneas de investigación, como el estudio de la influencia de la personalidad, factores cognitivos, la motivación u otros indicadores referentes al entorno y al bienestar personal de los estudiantes (Caballero-García y Sánchez-Ruíz, 2021),

así como el impacto de propuestas, programas e iniciativas educativas (Bolden et al., 2020). Todo ello mediante el uso de una gran variedad de instrumentos de recolección de datos y diferentes diseños de investigación (Sahin et al., 2023; Hernández-Torrano y Ibrayeva, 2019). Este enfoque polivalente del estudio de la creatividad incluye la evaluación por expertos, como el cuestionario CAT (*Consensual Assessment Technique:* Amabile, 1982), autoinformes, como el CAQ (*Creative Achievement Questionnaire:* Carson et al., 2005) y multitud de pruebas basadas en el pensamiento divergente, como el popular TTCT (*Torrance Test of Creative Thinking:* Torrance, 1966), por citar únicamente algunos de los más importantes.

Esta gran diversidad ha dado lugar a cierta controversia entre los investigadores de este campo, ya que esta desmembración podría suponer una barrera para comprensión holística del constructo de la creatividad y de los mecanismos que lo configuran (Barbot et al., 2019). Por esta razón, estos últimos años se han publicado diversos trabajos recopilatorios con la finalidad de harmonizar la literatura existente alrededor de la evaluación de la creatividad (Long et al., 2022; Bolden et al., 2019; Snyder et al., 2019; Karwowski et al., 2019; Cotter y Silvia, 2019). Aparte de esto, también existe una creciente preocupación respecto a la necesidad de un mayor rigor, homogenización y transparencia a la hora de compartir los resultados de evaluación de la creatividad (Barbot et al., 2019). Solo consiguiendo estos estándares se podrá avanzar con paso firme en este campo de investigación, a pesar de la naturaleza poliédrica y compleja de la creatividad que no facilita ni mucho menos ser aprehendida (Barbot y Said-Metwaly, 2021).

De hecho, la cuestión acerca de la posible existencia de dominios creativos (cuántos y cuáles) ha sido motivo de discusión ya desde las primeras contribuciones a este campo (Guildford, 1950). Según queda mencionado, en la actualidad existe un gran consenso sobre la naturaleza multicomponencial de la creatividad, la cual

incluye aspectos (o dominios) tanto específicos, como más generales, así como factores sociales y culturales (Glaveanu et al., 2020; Baer, 2012). Además, recientes estudios de neuroimagen han proporcionado evidencias que refuerzan ese argumento (Sunavsky y Poppenk, 2020; Boccia et al., 2015).

Pero pocas teorías han tenido en este sentido el éxito de la conocida como Parque de Atracciones (Kaufman y Glaveanu, 2019), que propone cuatro puntos jerárquicos que permiten caracterizar cualquier dominio creativo en cuestión. El primero de ellos corresponde con requerimientos iniciales, que son imprescindibles en cualquier expresión creativa, como un ambiente propicio o un nivel cognitivo básico. Seguidamente, se encuentran las áreas temáticas, que corresponden a disciplinas como las ciencias, las lenguas o las artes. Posteriormente, se encuentran dominios específicos y micro-dominios, los cuales ya corresponden con áreas y tareas más concretas (Baer and Kaufman, 2005). Por ejemplo, se puede considerar que, dentro del área temática de las lenguas, se tiene el dominio de la escritura y la tarea (o micro-dominio) de creación de metáforas.

A este respecto, hay numerosos estudios centrados en dominios específicos de la creatividad, los cuales ayudan a dilucidar esa naturaleza polifacética del constructo (Said-Metwaly et al., 2017). Por ejemplo, el dominio científico (de Vries y Lubart, 2019), el lingüístico (Bergs, 2019), y otros relacionados con la música, las artes o las matemáticas (Leikin, y Sriraman, 2022; Kladder y Lee, 2019; Mansour, 2018; Erbas y Bas, 2015). Con todo, hay que recordar que el uso de cuestionarios basados en el pensamiento divergente sigue siendo la tónica general para evaluar la creatividad (Kapoor et al., 2021).

En este sentido, los investigadores actualmente abogan por adoptar un enfoque más formativo y complejo, que incluya la evaluación de múltiples dominios de la creatividad. Ese enfoque implica no solo evaluar de manera aislada diferentes dominios, sino

también las relaciones entre ellos (Long et al., 2022), así como tener en cuenta otros aspectos clave (personales, sociales y culturales) que influyen en la creatividad del individuo (Glavenau et al., 2020). Mediante esta aproximación, se pretende obtener un perfil creativo del alumnado, que servirá de hoja de ruta para dirigir y adecuar las acciones formativas, de acuerdo al nuevo marco legislativo, marcado por la LOMLOE (2020), y los esfuerzos internacionales, como los de la OCDE (2023).

3.3. HACIA UNA EVALUACIÓN FORMATIVA DE LA CREATIVIDAD

La obtención del perfil creativo del alumnado se aproxima en esta tesis como una evaluación formativa de la creatividad, tanto desde la perspectiva de los estudiantes, como también del profesorado. Por este motivo, se han explorado múltiples dominios de la creatividad mediante la realización de tareas variadas.

Uno de los dominios evaluados es la creatividad científica, al cual se ha prestado limitada atención en comparación a otros dominios, como el artístico o el lingüístico (Hernández-Torrano y Ibrayeva, 2020; Raj y Saxena, 2016). Cabe destacar también que este dominio de la creatividad difiere de otros en tanto a que se requiere de conocimiento y habilidades específicas relacionados con ciertas actividades científicas, como prácticas experimentales, o resolver problemas. Aun así, también se consideran esenciales otros aspectos como el pensamiento divergente y convergente, ya que permiten enfocar la educación científica de manera creativa (Yildiz y Yildiz, 2021; Zulkarnaen et al., 2018).

Por otro lado, se entiende que la habilidad de los estudiantes para desenvolverse en las materias STEM (acrónimo del inglés para *Science, Technology, Engineering and Mathematics*) es análoga a la de profesionales científicos, salvando las diferencias evidentes entre el

trabajo formal de investigación y la ciencia educativa (Kind and Kind, 2007). Por todo ello, nutrir la creatividad científica de los estudiantes es esencial, no solo para propiciar su futuro académico, sino también para favorecer su autoconcepto y motivarlos a continuar su formación científica, más allá de los límites de la Educación Secundaria (Xu, 2023; Tytler, 2014; Taskinen et al., 2013; Lent et al., 1986).

El primer paso para ello consiste en evaluar la creatividad científica de los estudiantes (Hu et al., 2023; Alves-Oliveira et al., 2022). Así, se han diseñado varios instrumentos con este propósito (Ayas and Sak, 2014; Hu and Adey, 2002; Hu et al., 2010), los cuales están basados en diferentes aspectos, como el conocimiento curricular científico o las habilidades para experimentar y analizar información, así como la generación de determinados productos científicos o la propuesta y resolución de problemas. Todos ellos convergen en la idea de que el descubrimiento científico parte de la observación y la curiosidad (Aschauer at al., 2022). En esta tesis, se ha utilizado el planteamiento de problemas científicos específicos y cotidianos, como instrumento de evaluación formativa de la creatividad científica (Hu et al., 2010), el cual se describirá en detalle en el Capítulo 5 de aspectos metodológicos.

Otro de los dominios estudiados en esta tesis es la creatividad lingüística, puesto que, en última instancia, la lengua es el vehículo que permite la expresión de la creatividad: "La lengua es un proceso de creación libre; sus leyes y principios son fijos, pero la manera en la cual se utilizan es infinitamente libre" (Chomsky, 2003, p. 402). Cabe destacar que la creatividad lingüística también puede emerger de no seguir esas normas preestablecidas (Sampson, 2016), por lo que aún no se ha conceptualizado completamente este dominio creativo (Alfonso-Benlliure, y Mínguez-López, 2022; Bergs, 2019). En este sentido, la teoría asociativa clásica (Mednick, 1962) establece que la creatividad implica conexiones entre conceptos aparentemente no

relacionados. Así, pues, diferentes instrumentos de evaluación se basan en esta teoría para medir la distancia semántica entre palabras como medida de la creatividad lingüística, fundamentada además por su relación con el pensamiento divergente (Beaty et al., 2023). Un estudio prometedor que sigue este enfoque es el desarrollado por Olson et al. (2021), el cual se vale de métodos computacionales algorítmicos para medir automáticamente la distancia semántica. Este último es precisamente el método utilizado en esta tesis para la evaluación de la creatividad lingüística en términos de distancia semántica y pensamiento divergente.

Sin embargo, no solo se puede evaluar este dominio de la creatividad de esta manera, también se puede recurrir al lenguaje figurativo. Particularmente, se considera que la producción de metáforas es la materialización última de la creatividad y, por tanto, sirve como un potente indicador de innovación lingüística (Bergs, 2019; McKerracher, 2016). En este contexto, se debe considerar la teoría de la atribución (Glucksberg, et al., 1997), la cual considera necesaria la existencia de una conexión abstracta, que permita establecer una característica común entre dos elementos aparentemente no relacionados. Por otro lado, también se debe tener en cuenta que la memoria semántica tiene un papel esencial a la hora de recordar múltiples elementos, que ayudan a la creación de esas relaciones originales y creativas (Kurman, 2020; Kenett y Faust, 2019). Además, determinadas habilidades metalingüísticas también son necesarias, aunque estas se adquieren durante la adolescencia (Kasirer y Mashal, 2018; Levorato y Carcari, 2002). De hecho, la habilidad para entender metáforas se relaciona directamente con la maduración cognitiva y semántica (Melogno et al., 2012), aunque esta puede no estar linealmente correlacionada con la capacidad de crearlas.

Por otro lado, también se ha explorado la creatividad del alumnado desde un punto de vista más general. Tradicionalmente,

esta perspectiva se ha evaluado mediante cuestionarios basados en el pensamiento divergente, como el tradicional TTCT y sus derivados (Torrance, 1972) o la conocida como tarea de usos alternativos (AUT, de sus siglas en inglés *Alternate Uses Task*) de Guilford et al. (1960), que es la que se ha utilizado en esta tesis. Particularmente, se ha aplicado la tarea propuesta en el cuestionario de creatividad "PIC-J", que consta de una elevada validez y fiabilidad con muestra de estudiantes españoles (Barraca et al., 2010; Artola et al., 2008). Esta consiste en generar usos inusuales o alternativos de objetos de uso diario, en este caso de un tubo de goma, lo cual proporciona una sólida evidencia de la capacidad del individuo de crear ideas originales.

No obstante, es importante considerar que este tipo de medidas tiene también limitaciones, principalmente relacionadas con su extrapolación a otros dominios de la creatividad, como el científico o el lingüístico, que implican múltiples factores más allá del pensamiento divergente (Reiter-Palmon et al., 2019; Kaufman et al., 2017; Runco y Acar, 2012). Como se ha matizado en contadas ocasiones, la creatividad es un constructo poliédrico que requiere de la conjunción de diferentes métodos de evaluación (Elisondo y Donolo, 2011) y que además esta influido por factores sociales y culturales. Por todo ello, esta tesis se vale también del cuestionario de creatividad general español "CREA" (Corbalán et al., 2003). Este destaca por combinar una aproximación clásica, basada en el pensamiento divergente, con un enfoque adicional basado en la formulación de problemas, el pensamiento lateral y el estudio de estilos cognitivos (Corbalán y Limiñana, 2010).

Finalmente, sabiendo que el profesorado influye de manera notable en el desempeño creativo de los estudiantes (Bereczki y Karpati, 2018), en este trabajo también se ha abordado la autopercepción creativa de los docentes de Educación Secundaria. Para ello, existen varios cuestionarios de tipo autoinforme, como el

Biographical Inventory of Creative Behaviors (BICB: Batey, 2007), o el *Creative Action Scale* (CAS: Elisondo, 2021). Sin embargo, uno de los más utilizados es el *Kaufman domains of Creativity Scale* (K-DOCS) (Kaufman, 2012), que ha sido traducido a multitud de idiomas, entre ellos el español (Elisondo et al., 2022; Echegoyen-Sanz y Martín-Ezpeleta, 2021). Este cuestionario contiene aspectos creativos, tanto de dominio general como de dominio específico, puesto que está basado en la teoría del Parque de Atracciones, mencionada anteriormente. Particularmente, incluye cinco dominios creativos (Cotidiano, Académico, Científico/Mecánico, Actuación y Artístico).

En definitiva, en esta tesis se ha pretendido realizar una evaluación formativa de la creatividad en el contexto de la Educación Secundaria. Para ello, se ha combinado las perspectivas de los dos actores principales en el escenario educativo: el alumnado y el profesorado, partiendo de instrumentos de evaluación consolidados y complementarios entre ellos.

Capítulo 4

Objetivos

Esta tesis tiene el objetivo general de evaluar diferentes dominios creativos en el alumnado de Educación Secundaria Obligatoria, así como analizar la autopercepción creativa del profesorado de dicha etapa, como pasos previos a la propuesta de cambios instruccionales y didácticos que impulsen la presencia de la creatividad en las aulas. De esta manera, se persigue entender la situación de la creatividad en el sistema educativo español y una etapa clave de la formación de las personas. A partir de este objetivo general, se han planteado diferentes preguntas de investigación que estructuran la tesis y dirigen el posterior enfoque metodológico:

- ¿Cuál es el nivel de creatividad en los dominios científico y lingüístico del alumnado de Educación Secundaria Obligatoria? ¿Y su nivel de creatividad general?
- ¿Existen diferencias estadísticamente significativas entre los niveles de la dicha etapa educativa?
- ¿Y en función del género de los estudiantes?
- ¿Existe correlación entre los diferentes dominios de la creatividad estudiados?
- ¿Cuál es la autopercepción creativa del profesorado de Educación Secundaria?
- ¿Existen diferencias estadísticamente significativas en función de su género o edad?
- ¿Y en función de su área de especialización o los años de experiencia profesional?

Para dar respuesta a estas preguntas, se plantean los siguientes objetivos específicos:

- **Objetivo 1 (O1)**: Evaluar cuantitativamente la creatividad científica en el alumnado de 1.º, 2.º, 3.º y 4.º curso de la etapa de Secundaria.
- **Objetivo 2 (O2)**: Evaluar cuantitativa y cualitativamente la creatividad lingüística en el alumnado de 1.º, 2.º, 3.º y 4.º curso de la etapa de Secundaria.
- **Objetivo 3 (O3)**: Evaluar la creatividad general en el alumnado de 1.º, 2.º, 3.º y 4.º curso de la etapa de Secundaria.
- **Objetivo 4 (O4)**: Explorar la existencia de diferencias significativas en los resultados obtenidos en función del nivel educativo.
- **Objetivo 5 (O5)**: Explorar la existencia de diferencias significativas en los resultados obtenidos en función del género.
- **Objetivo 6 (O6)**: Determinar el grado de correlación entre los distintos dominios de la creatividad en el alumnado.
- **Objetivo 7 (O7)**: Evaluar la autopercepción creativa del profesorado de Educación Secundaria Obligatoria.
- **Objetivo 8 (O8)**: Explorar la existencia de diferencias significativas en los resultados obtenidos en función del género y la edad de los docentes.

- **Objetivo 9 (O9)**: Explorar la existencia de diferencias significativas en los resultados obtenidos en función del del área de especialización y los años de experiencia.

Capítulo 5

Aspectos Metodológicos

La investigación que nutre los artículos que componen esta tesis doctoral se desarrolló durante los cursos académicos 2020-2021, 2021-2022, 2022-2023 y 2023-2024. La información detallada en este capítulo se encuentra sujeta a la normativa del Comité Ético de la Universitat de València, por tanto, se omiten todos los nombres de los centros educativos colaboradores y otros datos que puedan atentar al anonimato.

5.1. Diseño de la investigación y participantes

El marco del estudio presentado en este trabajo corresponde a una investigación cuasi-experimental y exploratoria (Cohen et al., 2002). Se utilizaron instrumentos de evaluación de diferentes dominios de la creatividad, previamente validados, para la realización de un análisis mixto cuantitativo y cualitativo. En los casos necesarios, esos cuestionarios fueron traducidos al español o valenciano, con la ayuda de dos filólogos expertos que revisaron los textos exhaustivamente. En todo momento, se siguieron las directrices del Comité de Ética de la Universitat de València. Se pidió la colaboración a una selección de centros educativos de Educación Secundaria, escogidos por conveniencia. Aquellos dispuestos a colaborar en el estudio, recibieron información detallada acerca del proceso que se desarrollaría durante la investigación y del tratamiento anonimizado de los datos recopilados. En total, 8 centros educativos de la Comunitat Valenciana, tanto de zonas rurales como urbanas, accedieron a participar. De manera que los correspondientes equipos directivos, familias y responsables legales del alumnado firmaron un documento de consentimiento informado.

El estudio se llevó a cabo durante sesiones típicas de clase (de aproximadamente 50 minutos), en las cuales el alumnado realizó los cuestionarios pertinentes a modo de tareas de aula. Cabe destacar que, de todos ellos, un porcentaje correspondía a estudiantes de la

investigadora, que por aquel entonces trabajaba como profesora en un instituto. En cualquier caso, los cuestionarios fueron en todos los casos presentados al alumnado por la investigadora, siempre acompañada del docente responsable del grupo-clase cuando no era ella misma. Los datos demográficos (debidamente anonimizados) y los estadísticos descriptivos de la muestra se encuentran detallados en profundidad en los artículos reproducidos en el Anexo I de esta tesis.

5.2. INSTRUMENTOS DE INVESTIGACIÓN

Por un lado, la creatividad científica cotidiana (DSC, abreviatura de sus siglas en inglés) y la específica (SSC, abreviatura de sus siglas en inglés) se evaluaron mediante el cuestionario desarrollado por Hu et al. (2010), que se basa en habilidades de formulación de problemas y combina dos tipos de instrucción: abierta y cerrada. Esta configuración está dirigida a evaluar todos los resultados potenciales relacionados con la búsqueda de problemas científicos, tanto derivados de observaciones cotidianas, como de conocimientos específicos.

Las instrucciones del cuestionario se mostraron en forma de diapositivas durante la sesión de clase. Los estudiantes tuvieron un total de 16 minutos (8 minutos para cada ítem) para completar el cuestionario. En primer lugar, se pidió a los estudiantes que generaran preguntas relacionadas con las ciencias, basadas en sus experiencias de vida/diarias y su propia curiosidad, desde tantas perspectivas como pudieran y lo más originales posible (instrucción abierta). En segundo lugar, se pidió al alumnado que generaran tantas preguntas científicas como fuera posible relacionadas con una imagen de un astronauta en la luna (instrucción cerrada). El proceso de puntuación se basó en la conceptualización de la creatividad de Torrance (1972).

En consecuencia, las preguntas generadas por los estudiantes fueron evaluadas según su fluidez, la cual corresponde al número de preguntas generadas por cada estudiante; la flexibilidad, que se califica como el número de áreas de conocimiento utilizadas para generar esas preguntas; y la originalidad, que se basa el porcentaje de frecuencia de aparición de una determinada pregunta (2 puntos de originalidad si el porcentaje de frecuencia es inferior al 2%, 1 punto si la frecuencia está entre 5 % y 10%, y 0 puntos si es superior al 10%). La puntuación total de cada dimensión científica se calculó como la suma de las puntuaciones de las tres categorías mencionadas.

Las percepciones y el interés de los estudiantes hacia las ciencias se evaluaron con un cuestionario tipo Likert de 4 puntos, adaptado de una encuesta de alfabetización científica validada (Wu et al., 2019; Huang, 2012). Por un lado, los ítems correspondientes a la dimensión "percepciones" se basaron en conceptos epistemológicos y ontológicos, en conjunción con supuestos sobre la influencia de la ciencia y la tecnología en la sociedad (Osborne et al., 2003). Por otro lado, la dimensión de "interés" se basó en la conceptualización del disfrute y la motivación intrínseca respecto al aprendizaje de las ciencias (Ryan y Deci, 2009) y la participación en actividades científicas de divulgación, como fuente de experiencias de ocio (Nugent et al., 2015). Finalmente, la dimensión "expectativas" se evaluó a través de ítems de la sección ST113 (actitudes de los estudiantes hacia las ciencias y expectativas respecto a carreras científicas) de las pruebas PISA 2015 (OCDE, 2016), los cuales están basados en la motivación instrumental, en relación a futuros estudios o carreras (Wigfield y Eccles, 2000).

En cuanto a la creatividad lingüística, esta se evaluó mediante tareas diferentes, basadas tanto en el pensamiento divergente, como en la distancia semántica y la generación de metáforas. La primera tarea fue desarrollada por Olson et al. (2021). En ella se pidió a los estudiantes que escribieran diez sustantivos que fueran lo más

diferentes posible entre sí, en todos los significados y usos de las palabras posibles (por ejemplo, *canción* y *hormiga*). Se descartaron todas las palabras que pertenecían a otras categorías sintácticas (por ejemplo, verbos como *cantar* o adjetivos como *hermoso*) y se computaron las primeras siete palabras correctas para cada estudiante. El proceso de puntuación se realizó mediante un algoritmo computacional, desarrollado por los autores, el cual se encuentra disponible en línea (Olson et al., 2021).

La segunda tarea consistía en la generación de metáforas y se realizó según un modelo desarrollado por Levorato y Cacciari (2002) y posteriormente adaptado por Kasirer y Mashal (2018). En este caso, se pidió a los estudiantes que idearan metáforas para describir un total de diez elementos. Cada uno de esos elementos se hacía referencia a un sentimiento o emoción particular, por ejemplo, felicidad, tristeza, euforia o frustración. Previamente al proceso de puntuación, se descartaron las respuestas inapropiadas (descontextualizadas o vacías) y luego se clasificaron las respuestas en tres categorías: metáforas novedosas, las que eran únicas y originales (3 puntos); metáforas convencionales, las que se utilizan en el lenguaje común (2 puntos); y respuestas literales, que eran meras descripciones o analogías sin significado figurado (1 punto). Cabe mencionar, que todas las metáforas generadas por el alumnado fueron evaluadas por dos investigadores (uno de ellos filólogo). Aquellos ítems con discrepancias fueron discutidos hasta llegar a un consenso y la confiabilidad entre ambos investigadores fue de un 85%

Finalmente, la creatividad general se evaluó a partir de dos cuestionarios complementarios, que son ampliamente utilizados en el contexto que se enmarca esta tesis y que, además, cuentan con amplia validez y fiabilidad con muestra española. Como se expuso en el marco teórico, uno de ellos es el conocido como cuestionario PIC-J, particularmente la sección de la tarea de usos alternativos (Artola et al., 2008). Para abordar esta tarea, basada a su vez en el

instrumento AUT de Guilford et al. (1960), los estudiantes idearon aplicaciones inusuales para un tubo de goma, considerando válido cualquier tamaño y forma e incluso interconexiones entre diferentes tubos. El procedimiento de puntuación se basa en las categorías de fluidez, flexibilidad y originalidad, descritas anteriormente.

El otro cuestionario que permitió evaluar la creatividad general fue el CREA (Corbalán et al., 2003). Se articuló una última actividad que instaba al alumnado a generar preguntas a partir de la observación de una imagen, poniendo así en marcha diferentes procesos creativos que vinculan la representación mental de la imagen observada con el mapa de representaciones mentales de los estudiantes. El proceso de revisión de los cuestionarios se inició invalidando las preguntas generadas totalmente fuera de contexto o repetitivas. Posteriormente, se asignó 1 punto a cada pregunta simple, mientras que las preguntas dobles o triples (que reflejan dos o tres fenómenos o acciones diferentes) se calificaron con 2 y 3 puntos, respectivamente.

Finalmente, la autopercepción creativa del profesorado se evaluó mediante el cuestionario K-DOCS (Kaufman, 2012). Este incluía 50 ítems relacionados con 5 dominios de creatividad diferentes: Cotidiano, 11 ítems; Académico, 11 ítems; Actuación, 10 ítems; Científico/Mecánico, 9 ítems; y Artístico, 9 ítems. Se pidió a los participantes que se compararan con iguales (de edad y experiencia similar), para evaluar su propio desempeño en tareas particulares, como, por ejemplo, "escribir un poema" (Actuación), "escribir un programa de ordenador" (Científico/Mecánico), "escribir una carta al editor" (Académico), "enseñar a alguien cómo hacer algo" (Cotidiano) y "apreciar una pintura hermosa" (Artístico). Así pues, los participantes indicaban el grado en que desarrollarían esas tareas creativas, en comparación con sus iguales, utilizando una escala Likert de 5 puntos, tal y como sigue: de manera mucho menos creativa (1), menos creativa (2), ni más ni menos creativa (3), más

creativa (4) o mucho más creativa (5). La validez de la traducción al español de este cuestionario, analizada mediante el método Alfa de Cronbach (Elisondo et al., 2022; Echegoyen-Sanz y Martín-Ezpeleta, 2021), se confirmó con valores de alfa superiores a 0.76 para todos los dominios. El recabado de datos se realizó mediante una versión online del cuestionario con el fin de facilitar la participación de los docentes.

5.3. ANÁLISIS DE LOS DATOS

El análisis estadístico de los datos recopilados se realizó mediante el software SPSS. En primer lugar, se calcularon la media y la desviación estándar para cada una de las dimensiones de creatividad estudiadas, teniendo en cuenta una determinada muestra de estudiantes y dependiendo del trabajo considerado. En segundo lugar, se utilizó la prueba de Kolmogorov-Smirnov para evaluar la normalidad de las distribuciones. Luego, las diferencias de género se investigaron utilizando la prueba t de Student para muestras independientes (variables distribuidas normalmente) o la prueba U de Mann-Whitney (variables no normales). En los artículos que así lo requerían, las diferencias entre niveles de la etapa educativa se estudiaron utilizando ANOVA de un factor (variables distribuidas normalmente) o la prueba de Kruskal-Wallis (variables no normales).

En cuanto al análisis de diferencias significativas según grupo de edad, años de experiencia y área de especialización del profesorado, se utilizó o bien ANOVA unidireccional (distribuciones normales), o bien la prueba de Kruskal-Wallis (distribuciones no normales). Asimismo, se llevaron a cabo pruebas *post hoc (*utilizando la prueba de Bonferroni), según fue necesario para explorar más a fondo las diferencias entre ciertos grupos de docentes.

Finalmente, la correlación entre variables se analizó mediante la correlación de Pearson o de Spearman, en función de las

características de cada variable. En todas las pruebas el nivel de significación fue de 0.05. La magnitud del tamaño del efecto se evaluó según la clasificación de Cohen para Ciencias Sociales (1988), calculando el parámetro g de Hedges o, alternativamente, aplicando la fórmula correspondiente para datos no paramétricos cuando fue necesario (Field, 2018).

Capítulo 6

Principales Resultados

En este capítulo se recopilan los resultados más relevantes de los cuatro artículos que componen el compendio presentado en esta tesis. Cada uno de ellos nutre el objetivo principal de la misma aportando evidencias concretas. El primero de ellos se centra en estudiantes del primer nivel de la etapa de Educación Secundaria. En él se evalúa la creatividad científica (cotidiana y especifica), la lingüística (generación de metáforas) y la general (cuestionario CREA). Por su parte, el segundo se ocupa del otro extremo de la etapa educativa (cuarto nivel). En este caso, se explora la creatividad lingüística (generación de metáforas y denominación de palabras no relacionadas) y se realizan tareas de creatividad general (tarea de usos alternativos del cuestionario PIC-J). En el tercer artículo, se amplía el espectro del estudio y se abarcan todos los niveles de la etapa educativa (primero, segundo, tercero y cuarto curso de la Educación Secundaria Obligatoria). En esa ocasión, la evaluación de la creatividad incluía las dimensiones científica (cotidiana y especifica) y lingüística (generación de metáforas). Finalmente, el cuarto artículo toma como eje la autopercepción creativa del profesorado en los dominios Cotidiano, Académico, Actuación, Científico/Mecánico y Artístico, para obtener así una visión completa del papel que juega la creatividad en ese escenario, implicando a todos los actores del proceso educativo.

6.1. PRIMER ARTÍCULO: "THE TURNING POINT: SCIENTIFIC CREATIVITY ASSESSMENT AND ITS RELATIONSHIP WITH OTHER CREATIVE DOMAINS IN FIRST YEAR SECONDARY STUDENTS"

Como se ha presentado de manera breve en la introducción (Capítulo 2), en este primer artículo se exploró la creatividad científica (cotidiana y específica), así como la creatividad lingüística (en términos de generación de metáforas) y la creatividad general

(medida como búsqueda de problemas creativos), en estudiantes de primer curso de la etapa de Educación Secundaria.

En cuanto a los resultados asociados a la creatividad científica, estos se presentan divididos en los dominios cotidiano (DSC) y específico (SSC). Ambos se evaluaron de acuerdo a las preguntas generadas por los estudiantes y en base a su la fluidez, flexibilidad y originalidad (Hu et al., 2010).

En relación con la fluidez, cada estudiante formuló aproximadamente 9 preguntas. En este punto cabe destacar que se observó una tendencia general entre los estudiantes a plantear preguntas similares. Por ejemplo, para la DSC, las cuestiones se centraron en el Universo y la astronomía, mientras que las preguntas de SSC giraron en torno a la composición y morfología de la luna, así como la presencia de aire, oxígeno o atmósfera en ella. Respecto a la flexibilidad, se encontró que el alumnado utilizaba aproximadamente 4 campos de conocimiento diferentes para formular sus preguntas. Las categorías más recurrentes fueron "astronomía" y "cuerpo/salud humana" para DSC, así como "composición de la luna y meteorología" y "tecnología y comunicaciones" para SSC. Finalmente, considerando la originalidad de las preguntas generadas por el alumnado, solo una de las nueve preguntas promedio por estudiante se consideró inusual o única, en base a su frecuencia estadística de aparición. Esas preguntas consideradas originales (con un porcentaje de frecuencia de aparición menor del 2%) estaban relacionadas con acciones o fenómenos cotidianos, como la fabricación de pintura, el mecanismo de funcionamiento de un microondas, las causas del envejecimiento o la sensación de dolor. De manera análoga a los resultados reportados por Hu et al. (2010), los estudiantes exhibieron una originalidad limitada y tendieron a utilizar campos de conocimiento científicos más tradicionales u obvios, como astronomía y salud (DSC) o tecnología y física (SSC).

En cuanto a los resultados de la creatividad lingüística, estos fueron similares a los correspondientes a la creatividad científica. El alumnado mostró un rendimiento moderado-bajo en la tarea de generación de metáforas. Así pues, en sus respuestas existía un elevado porcentaje de respuestas literales, a menudo relacionadas con sentimientos típicos adolescentes y analogías con el ámbito escolar, en contraposición a la existencia de un porcentaje extremadamente escaso de respuestas consideradas metáforas originales. Estos resultados se encuentran en línea con estudios previos (Kasirer y Mashal, 2018): de manera general, los estudiantes tendieron a generar analogías basadas en sus experiencias más cercanas, en lugar de crear metáforas novedosas.

Respecto a la creatividad general, esta se abordó mediante la generación de preguntas a partir de la observación de una imagen (Corbalán et al., 2003). La mayoría de las preguntas generadas por el alumnado se centró en los sentimientos, la edad, la apariencia, la vestimenta, la ocupación y la ubicación de personajes de la imagen. Además, se obtuvo un índice porcentual que demostraba la limitada creatividad del alumnado, aunque reflejaba también una moderada apertura y versatilidad de los esquemas cognitivos de los estudiantes al observar estímulos visuales.

Al examinar las diferencias de género, las alumnas obtuvieron puntuaciones más altas en todas las dimensiones de la creatividad, aunque particularmente en la SSC y la creatividad general. Las pruebas U de Mann-Whitney revelaron diferencias de género estadísticamente significativas en todas las dimensiones de la creatividad, excepto la DSC, con tamaños del efecto de medios a moderados. Estos resultados están en consonancia con los de Nakano et al. (2021) y muestran que los estereotipos de género no siempre son exactos puesto que generalmente las mujeres son consideradas seres creativos, especialmente en los ámbitos artístico y escénico (Elisondo, et al., 2022).

El análisis de la correlación entre las dimensiones de la creatividad estudiadas reveló correlaciones positivas y significativas entre todas ellas. Sin embargo, se observó una mayor correlación entre las dimensiones científicas (DSC y SSC), que entre las dimensiones científica y lingüística. Cabe decir que, aunque estos resultados pueden reforzar, a priori, el debate sobre el constructo general de la creatividad (Snyder et al., 2019; Baer, 2012), el alumnado creativo lo era particularmente en uno de los dominios estudiados, cosa que se puede relacionar tanto con sus conocimientos previos, como su perfil, intereses y motivaciones. Aun así, ello también depende del tipo de tarea creativa planteada y los procesos neuronales implicados en su resolución (Kleibeuker et al., 2013).

6.2. SEGUNDO ARTÍCULO: "ASSESSING THE LINGUISTIC CREATIVITY DOMAIN OF LAST-YEAR COMPULSORY SECONDARY SCHOOL STUDENTS"

Este artículo del compendio se centra en explorar los vínculos entre la producción creativa de metáforas y diferentes tareas de pensamiento divergente (tarea de usos alternativos y denominación de palabras no relacionadas). Particularmente, el foco de esta investigación está puesto en alumnado del último nivel de la etapa de Educación Secundaria Obligatoria, ya que sus competencias lingüísticas pueden estar suficientemente desarrolladas para afrontar las tareas creativas lingüísticas propuestas.

Respecto a los resultados asociados a la tarea de nombrar palabras no relacionadas, estos denotan una capacidad creativa moderada (Olson et al., 2021). En el caso de la tarea de nombrar usos alternativos, las puntuaciones de originalidad y flexibilidad fueron limitadas, puesto que las respuestas de los estudiantes generalmente se enmarcaban en las mismas categorías, todas ellas asociadas a perfiles de baja originalidad (Barraca et al., 2010). Sin embargo, los

resultados correspondientes a la tarea de generación de metáforas fueron particularmente deficientes. Esto apunta a que los estudiantes no son capaces de producir metáforas novedosas de forma adecuada y recurren a analogías o ejemplos, en lugar de expresiones figurativas, ya sean convencionales o ideadas por ellos mismos.

Este hallazgo puede estar relacionado con el hecho de que la comprensión de las metáforas no tiene porqué proporcionar al alumnado las destrezas necesarias para crear nuevas metáforas. En línea con esto, se ha constatado que la comprensión y generación de metáforas no van siempre de la mano, aunque comparten activaciones de regiones cerebrales comunes (He et al., 2020; Benedeck et al., 2014). Lamentablemente, esta situación es análoga a la descrita en el artículo anterior, con el agravante de que en aquel los participantes eran de primer curso de la Educación Secundaria Obligatoria y en este nos encontramos en el otro extremo de la etapa educativa.

En cuanto a las diferencias de género en las diferentes tareas de creatividad, los y las estudiantes obtuvieron puntuaciones diferentes, con una destacada excepción en la tarea de nombrar palabras no relacionadas. Las alumnas obtuvieron calificaciones más altas en las tareas de generación de metáforas y usos alternativos, dando lugar a diferencias estadísticamente significativas. Como en el caso del artículo anterior, cabe señalar que el papel del género en el desempeño de la creatividad no se comprende del todo; puesto que entran en juego no solo las preferencias personales, sino también estereotipos y factores socioculturales que tienen que ver con la implicación con la tarea creativa (Taylor et al., 2023; Artola et al., 2021).

Finalmente, se estudió la correlación entre los resultados obtenidos para las diferentes tareas creativas, de manera que se detectaron correlaciones positivas entre las puntuaciones de todas ellas, a pesar del bajo valor del coeficiente de correlación. Sin

embargo, solo se encontraron correlaciones significativas entre la tarea de generación de metáforas y las otras dos tareas (denominación de palabras no relacionadas y propuesta de usos alternativos). En consecuencia, los estudiantes que tuvieron un alto desempeño en la generación de metáforas novedosas, también lograron obtener altas puntuaciones al nombrar palabras no relacionadas y proponer usos alternativos a un objeto. Sorprendentemente, la tarea de nombrar palabras no relacionadas no se correlacionó con la capacidad de encontrar aplicaciones no convencionales de un objeto ordinario (tarea de usos alternativos), a pesar de que ambas tareas se encuentran claramente asociadas con habilidades de pensamiento divergente.

Ese tipo de correlaciones han generado mucho debate, ya que están relacionadas con la naturaleza general/específica del constructo creatividad y los procesos implicados en la creación, los cuales aún no se han discernido en su totalidad (Taylor y Kaufman, 2021; Baer, 2015). Por un lado, se cree que la generación de metáforas implica un conjunto complejo y diverso de mecanismos cognitivos, como la atención selectiva, el pensamiento divergente y las funciones ejecutivas, que probablemente promueven procesos como la flexibilidad cognitiva y el control inhibitorio (Menashe et al., 2020)

Dadas las correlaciones obtenidas en este trabajo, las tareas de generación de metáforas, usos alternativos y denominación de palabras no relacionadas pueden requerir una gran versatilidad cognitiva para combinar conceptos remotos e inhibir asociaciones obvias, lo que resulta en esa correlación significativa entre las tareas. Además, todo ello está relacionado con la memoria episódica, que contribuye a la producción de ideas dependiendo de las experiencias personales y el perfil del alumnado (Chen et al., 2023).

6.3. TERCER ARTÍCULO: "SCIENTIFIC AND LINGUISTIC CREATIVE DOMAINS IN SECONDARY EDUCATION"

En el tercer artículo del compendio se investiga tanto la creatividad científica (cotidiana, DSC y específica, SSC), como la lingüística (creación de metáforas). Sin embargo, el foco en este caso está puesto en todos y cada uno de los niveles que conforman la etapa de Educación Secundaria Obligatoria (primero, segundo, tercero y cuarto curso). De esta manera, se obtiene una visión global que complementa y amplia los resultados de los dos artículos anteriores, y que, además, proporciona información respecto al estado del desarrollo de las competencias creativas en las aulas.

Cabe destacar que los resultados obtenidos son similares a los descritos en los dos artículos anteriores. En el caso de la dimensión cotidiana de la creatividad científica (DSC), un gran número de preguntas estaban relacionadas con el Universo y el cuerpo humano, aunque también con las conexiones inalámbricas y las herramientas TIC. Por otro lado, para dimensión específica de la creatividad científica (SSC) las preguntas más frecuentes estaban relacionadas con la gravedad, la presencia de aire en la luna o la posibilidad de vida en la luna. Como ocurría anteriormente, se detectaron diferencias de género. Concretamente, las alumnas mostraron una mayor capacidad creativa para formular problemas científicos. Nuevamente, estos resultados están en consonancia con otros estudios, según los cuales el autoconcepto marcado por el rol de género condiciona en gran medida la creatividad del alumnado (Nakano et al., 2021).

En cuanto a los resultados de la DSC y la SSC en función del nivel educativo, los valores para ambos dominios creativos son similares para los dos primeros niveles, con un ligero aumento en el tercero y un posterior descenso en el último nivel de la etapa educativa. El primer incremento se puede asociar con el desarrollo de

habilidades y la ampliación de conocimiento científico en esta etapa. Por otro lado, el descenso en el cuarto año puede estar relacionado con las vicisitudes propias de la edad adolescente, una baja motivación y la especialización dentro de la etapa educativa (Hu et al., 2010). Sin embargo, cabe añadir que no se encontraron diferencias estadísticamente significativas entre los cuatro cursos, para ninguno de los dos dominios de la creatividad científica estudiados (DSC y SSC).

Por lo que respecta a los resultados correspondientes a la creatividad lingüística, estos también fueron similares a los descritos en los artículos anteriores. Concretamente, en el análisis cualitativo de las metáforas generadas por los estudiantes se detectaron numerosas alusiones a aspectos académicos y a la soledad como sinónimo de fracaso. En el caso de las metáforas que generaron y se clasificaron como nuevas (las puntuadas con tres puntos), el alumnado utilizó principalmente la cosificación o la analogía con sentimientos generados en determinadas situaciones. Al igual que en el caso de la creatividad científica, las alumnas obtuvieron mayores puntuaciones. Si bien estos resultados son contrarios a los presentados por Kasirer y Mashal (2018), se debe considerar que su muestra fue más pequeña (54 participantes) y que el rol del género en el desempeño de la creatividad es complejo y no se conoce con exactitud (Taylor et al., 2023; Artola et al., 2021).

En cuanto a las diferencias en la creación de metáforas entre niveles de la etapa educativa, la tendencia es similar a la encontrada para la creatividad científica: un aumento, en este caso, entre primero y segundo; valores similares para segundo y tercero; y una disminución en el cuarto año. De manera análoga a la descrita anteriormente, estos resultados podrían explicarse por el estudio de la metáfora como figura literaria, en segundo y tercero de Educación Secundaria Obligatoria, así como el desarrollo de la capacidad de abstracción/atribución. La caída en el cuarto curso se puede asociar

nuevamente a la especialización, a la adolescencia y a un descenso de la motivación del alumnado. Cabe resaltar que, en este caso, y a diferencia de lo que ocurre con la creatividad científica, las diferencias observadas sí fueron estadísticamente significativas.

Finalmente, el estudio de la correlación entre la creatividad científica y la lingüística resultó ser relevante, atendiendo al debate entre la existencia de dominios específicos de la creatividad y la consideración de la creatividad como un constructo general (Huang y Wang 2019). Particularmente, se encontraron correlaciones positivas significativas entre todos los dominios creativos estudiados (creatividad científica DSC, creatividad científica SSC y creatividad lingüística), lo cual indica que el alumnado que es creativo en un dominio, también lo es en los otros dos dominios. Si bien este resultado, a priori, podría señalar a un constructo general de la creatividad, es necesario tener en cuenta ciertas consideraciones.

En primer lugar, se obtuvo una correlación muy alta entre los dos dominios de la creatividad científica estudiados (DSC y SSC), lo que indica una presumible relación entre la creatividad científica cotidiana y la específica. No obstante, la correlación entre los dos tipos de creatividad científica y la creatividad lingüística, aunque positiva, fue claramente menor. Así pues, estos resultados señalan que un determinado alumno que presente una buena capacidad creativa, mostrará a su vez un desempeño creativo mayor o menor en ciertos dominios, dependiendo de su perfil, intereses y habilidades en las áreas de conocimiento asociadas (Chen et al., 2023).

6.4. CUARTO ARTÍCULO: "CREATIVE SELF-PERCEPTION OF SPANISH SECONDARY TEACHERS"

En los tres primeros artículos del compendio, el tema de investigación ha sido la creatividad del alumnado de Educación Secundaria Obligatoria, particularmente en los dos niveles

correspondientes a los dos extremos de dicha etapa. Sin embargo, el cuarto artículo del compendio se focaliza en la autopercepción creativa del profesorado, puesto que se conoce que tiene una influencia notable en el desarrollo de la creatividad en las aulas (Bereczki y Karpati, 2018).

Los resultados de la investigación apuntaron a que los profesores de Secundaria tienen una autopercepción creativa de moderada a alta en los diferentes ámbitos educativos. En particular, las puntuaciones más altas se obtuvieron en el dominio Cotidiano, seguido de los dominios Artístico y Académico. Sin embargo, los dominios Actuación y Científico/Mecánico tienen perfiles de autopercepción de creatividad más bajos, siendo el último el que presenta valores más bajos entre el profesorado de Educación Secundaria. Estos resultados son análogos a estudios publicados anteriormente para futuros docentes de Educación Primaria españoles (Pont-Niclòs et al., 2022; Martín-Ezpeleta et al., 2022; Echegoyen-Sanz y Martín-Ezpeleta, 2021) y para una muestra de perfiles españoles más variopintos (Elisondo et al., 2022).

Al analizar las diferencias de género en la autopercepción creativa de los docentes de Secundaria, las profesoras y profesores obtienen puntuaciones ligeramente diferentes en los dominios evaluados. Ellas obtuvieron puntuaciones más altas en los dominios de Actuación y Artístico. Por el contrario, ellos obtuvieron puntuaciones más altas en los dominios Cotidiano, Académico y Científico/Mecánico. Sin embargo, la prueba t de Student (variables normalmente distribuidas) y la prueba U de Mann-Whitney (variables no normalmente distribuidas) solo mostraron diferencias estadísticamente significativas según el género para el dominio Científico/Mecánico, con un efecto de gran tamaño.

Estos resultados son similares a los reportados en otros estudios, en los cuales los hombres presentan una elevada autopercepción de la creatividad en dominios relacionados con la

ciencia, mientras que las mujeres obtienen hacen lo propio en dominios artísticos (Elisondo et al., 2022; Pont-Niclòs, 2022; Kaufman et al., 2009). Cabe destacar en este contexto que algunos estudios han cuestionado estos hallazgos dada la tendencia general de las mujeres a subestimar sus propias habilidades (Kaufman, 2019).

Por otro lado, al analizar la influencia de la edad o los años de experiencia en la docencia, no se diferencias significativas entre ningún grupo de docentes. Esto concuerda con estudios previos que sugieren que la experiencia y la edad de los docentes no tienen un efecto notable en su autopercepción creativa (Kettler et al., 2018). Lamentablemente, este hecho apunta hacia el carácter estático generalizado del desarrollo profesional de los docentes, debido en parte a la falta de programas de formación, apoyo y capacitación que promuevan la integración de la creatividad en la Educación (Hernández-Torrano y Ibrayeva, 2020; Vincent-Lancrin et al., 2019; Harris y De Bruin, 2018).

Por último, el estudio de la autopercepción creativa en función del área de especialización del profesorado de Educación Secundaria reveló que los docentes de Artes y Educación Física tienen una mayor autopercepción de su creatividad. Asimismo, solo se encontraron dominios de la creatividad para los que existía una diferencia estadísticamente significativa entre las diferentes disciplinas docentes: el dominio Científico/Mecánico y el Artístico. Para estudiar con más detalle la influencia de las áreas de especialización en la autopercepción creativa en cada dominio se llevó cabo un análisis *post hoc*.

Los resultados revelaron una fuerte correlación positiva entre la disciplina docente y la autopercepción creativa en según qué dominio. Por ejemplo, el profesorado de Artes tenía una autopercepción creativa elevada en el dominio Artístico. Este hecho puede estar asociado a la influencia de autoeficacia en un tema o área de conocimiento y las experiencias docentes previas (Perera et al.,

2019; Ozder, 2011). Las diferencias estadísticamente significativas se detectaron precisamente entre los profesores de Arte y el profesorado del resto de áreas de especialización investigadas (Ciencias Naturales, Matemáticas y Tecnología, Ciencias Sociales, Lengua y Literatura, Música, Educación Física).

Capítulo 7

Conclusiones, Limitaciones, Prospectiva e Implicaciones Educativas

En esta tesis se ha completado una medición objetiva de la creatividad en las aulas de Educación Secundaria y se han mostrado evidencias de la naturaleza poliédrica de este constructo denominado creatividad o pensamiento creativo. En los tres primeros artículos del compendio se ha analizado el desempeño creativo del alumnado de Educación Secundaria Obligatoria. Para ello, se han abordado tareas de aula que servían para evaluar la creatividad focalizadas en dominios creativos concretos, siendo estos el científico (cotidiano y específico), el lingüístico (con actividades de pensamiento divergente, distancia semántica y creación de metáforas) y el general (desde dos aproximaciones diferentes). Ha completado todo ello un último artículo que ha explorado la autopercepción creativa del profesorado, en tanto en cuanto los docentes desempeñan un papel fundamental para la promoción de la creatividad en el sistema educativo. Así, las conclusiones extraídas de todas estas investigaciones se pueden vertebrar alrededor de dos ejes: el alumnado y el profesorado.

En relación al primero, los resultados obtenidos apuntan hacia un desempeño moderado-bajo generalizado en todas las dimensiones creativas estudiadas. Concretamente, en el primer artículo del compendio se ha explorado la creatividad científica (cotidiana y específica), lingüística (creación de metáforas) y general (formulación de preguntas) del alumnado de primer curso de Educación Secundaria, mientras que en el segundo se ha estudiado la creatividad lingüística (denominación de palabras no relacionadas y creación de metáforas) y la general (usos alternativos) en el alumnado de último curso de la etapa Secundaria Obligatoria. En el tercer artículo, se ha analizado la creatividad científica (cotidiana y específica) y la lingüística (creación de metáforas) en el alumnado de todos los cursos de la etapa de Educación Secundaria Obligatoria. En la totalidad de los casos los resultados muestran una imagen mediocre de la creatividad, que llama la atención especialmente

cuando se cotejan los resultados entre los estudiantes más jóvenes y los mayores, cuyas diferencias son mínimas. Esto cabe interpretarse como que la creatividad no ha evolucionado significativamente al superar los cursos y madurar intelectualmente, en una etapa muy susceptible para ello (aunque menos que en los últimos cursos de la Educación Primaria). Se precisa de estudios longitudinales que ratifiquen estos resultados, pero en cualquier caso ha de valorarse como unos resultados negativos.

Así, se han culminado los **objetivos 1, 2, 3, 4, 5** y **6** de la tesis, puesto que se ha evaluado asimismo la posible existencia de diferencias estadísticamente significativas entre género y niveles, así como la correlación entre las dimensiones creativas estudiadas. En cuanto al estudio en función del género, cabe destacar que, aunque de manera general las estudiantes han mostrado competencias creativas más elevadas, el rol de los estereotipos socioculturales en este contexto no se conoce con exactitud. Es más, puede que, como se ha apuntado (Taylor y Barbot, 2021; Abraham, 2016), no se llegue a dilucidar en su totalidad debido a la gran cantidad de factores implicados, no solo interpersonales y colectivos, sino también intrapersonales y cognitivos. Como se anticipaba, atendiendo a las diferencias entre niveles dentro de la etapa, aunque se detectaron pequeñas fluctuaciones entre cursos, no se observó un desarrollo apreciable de la creatividad durante el transcurso de la etapa educativa estudiada.

Por lo que respecta a la correlación entre los diferentes dominios creativos estudiados, la correlación positiva detectada en la mayoría de ellos ha sumado evidencias que apuntan hacia el carácter multicomponencial del constructo de la creatividad. En la actualidad cada vez son más los expertos que se suman a esa descripción poliédrica de la creatividad (Taylor y Kaufman, 2021; Snyder et al., 2019; Baer, 2015) que en esta investigación se puede constatar.

Particularmente, en esta tesis se ha observado una correlación positiva elevada entre ambos dominios científicos estudiados (cotidiano y específico), así como otra correlación, no tan elevada pero aun así positiva, entre estos y el dominio lingüístico (creación de metáforas) y el general (formulación de preguntas). También se ha obtenido una correlación positiva entre la tarea de creación de metáforas y la tarea de denominación de palabras no relacionadas, así como la de usos alternativos, aunque no entre estas dos últimas.

Considerando estos resultados se puede concluir que el alumnado que es creativo lo es de manera general en todos los dominios, pero que destacará más en uno u otro dependiendo de su perfil particular. En esta explicación multicomponencial, se debe además considerar la influencia del conocimiento específico en cada uno de los dominios (Kleibeuker et al., 2013), aparte de los conocimientos (meta)lingüísticos (Chiappe y Chiappe, 2007). Y a todo ello se ha de sumar el papel que juegan ciertos mecanismos cognitivos en según qué tarea creativa, como, por ejemplo, el pensamiento divergente y convergente, la memoria semántica y episódica o las funciones ejecutivas (Chen et al., 2023; Menashe et al., 2020). Pero tampoco hay que olvidar el importante papel que juegan los intereses y motivaciones, el propio autoconcepto y demás factores relacionados con el bienestar personal (Caballero-García y Sánchez-Ruíz, 2021).

El segundo eje que vertebra las conclusiones extraídas de este trabajo se centra en el profesorado en activo de Educación Secundaria. Particularmente, se ha explorado su autopercepción creativa, analizando también la posible existencia de diferencias significativas en función del género y la edad de los docentes, así como de su área de especialización y los años de experiencia. Con ello, se han culminado los **objetivos 7**, **8** y **9** de esta tesis.

Los resultados obtenidos indican que el profesorado presenta una autopercepción creativa moderada-alta en todos los dominios

estudiados. Respecto a las diferencias entre géneros, únicamente fueron detectadas diferencias estadísticamente significativas en el caso del dominio Científico/Mecánico, siendo las profesoras las que se perciben como menos competentes creativamente en esa área. Como se ha comentado anteriormente, estos resultados pueden ser interpretados en términos de estereotipos tradicionales, aunque muchos otros factores pueden contribuir a ellos, complicando su comprensión (Elisondo et al., 2022). Sería interesante completar esta autopercepción con mediciones reales de la creatividad de los docentes, dando por buena la tesis tantas veces citada (Ruiz-del-Pino, 2022; Yates y Twigg, 2017; Chan y Yuen, 2014), de que para que los docentes canalicen la creatividad de sus estudiantes ellos han de hacerlo previamente.

Cabe destacar que ni la edad ni los años de experiencia producen cambios en la autopercepción creativa del profesorado, relevando el carácter estático de la formación docente. Surge así la necesidad de diseñar programas formativos para abordar este paradigma, no solo reforzando las competencias creativas docentes, sino también aportando información acerca del constructo de la creatividad y de su papel, esencial y transversal, en la educación actual (Cotter et al., 2022; Kaplan, 2019).

Una vez analizadas las conclusiones extraídas de ambos ejes es necesario considerar las limitaciones encontradas. En primer lugar, la muestra de alumnado y profesorado, aunque suficiente, podría ampliarse y deslocalizarse para abarcar diferentes regiones del país, obteniendo así una perspectiva más completa del sistema educativo español. En segundo lugar, los instrumentos utilizados, aun presentando elevada validez y fiabilidad, están sujetos a limitaciones inherentes a su diseño (Kapoor et al., 2021). Por este motivo se podría utilizar también una combinación de cuestionarios, autoinformes y tareas creativas que aportaran más evidencias a la relación entre las competencias creativas, el autoconcepto y los factores cognitivos,

motivacionales y de bienestar personal (Long et al., 2022; Taylor y Kaufman, 2021; Kaufman 2019).

A pesar de estas limitaciones, los estudios presentados en esta tesis apuntan hacia la importancia del replanteamiento del papel de la creatividad en la Educación Secundaria para salir al paso de los desafíos sociales, actuales y futuros (Tran et al., 2021). Se trata de entender que la creatividad es una competencia demasiado importante como para no situarla en el centro del tablero educativo, por mucho que exija un nuevo paradigma (Perignat y Katz-Buenincontro, 2019).

Ese cambio de paradigma debe comenzar por la propuesta de cambios instruccionales y didácticos concretos, que pasan antes que nada por contar con un profesorado que entiende técnicamente la creatividad y la importancia de atender a esta competencia en todos los cursos y materias. En este sentido, sería importante que se reforzara la formación en relación a la creatividad en el Máster Universitario en Profesor/a de Educación Secundaria para el caso de los docentes en formación; pero también que se impulsaran cursos destinados al profesorado a partir del Servicio de Formación del Profesorado o CEFIRE, por ejemplo. Estos cursos deberían ser capaces no solo de facilitar técnicas para activar la creatividad en las aulas, sino una oportunidad para reforzar la metacognición creativa de los docentes, que puede ser un camino extraordinariamente importante para que ayuden a sus discentes a reconocer su capacidad, actitud o resultados creativos. Merecería la pena monitorizar la evolución en la percepción de la creatividad del profesorado que completara su formación en materia de creatividad, así como de los cambios didácticos que introdujera y el impacto de los mismos en sus clases.

En este punto, conviene tener en cuenta también la pertinencia de poner en circulación un Plan Creativo de Centro, según viene impulsando el proyecto de investigación EVACREA (PID2021-

124333NB-I00, dirigido por los profesores Joan Josep Solaz-Portolés y Antonio Martín-Ezpeleta), y donde la que esto suscribe colabora, que, tomando como modelo el Plan Lector de Centro, sirva para impulsar medidas corales en los institutos en pro de la creatividad. Estas tienen que suponer la intensificación de un input creativo (exposiciones de diferente naturaleza y mezcla de disciplinas-estéticas, visitas de creadores, etc.) y harmonizar una metodología de enseñanza-aprendizaje donde se desafíe constantemente a los estudiantes a ir más allá, donde se les conduzca a buscar soluciones creativas, a activar el pensamiento divergente, a forzar los límites de la cotidianeidad en busca de la optimización.

Este enfoque es imprescindible si se quiere realmente canalizar la creatividad, que, como es bien sabido (por mucho que se lean publicaciones divulgativas en un sentido contrario), no se puede *desarrollar* como tal a partir de secuencias didácticas de pequeño alcance. Lo cierto es que para activar la creatividad de los estudiantes es necesario un trabajo de amplio espectro y naturalizado (no como un contrapunto innovador), transdisciplinar y transversal, es decir, a lo largo de todas las materias (según especifica la LOMLOE) y cursos de la Educación Secundaria, asegurando las mejores condiciones para que emerja la creatividad de todos los estudiantes, sea esta la que sea. El reto de nuevo es monitorizar el cambio en centros que se atrevan a introducir todos estos cambios, como actualmente está llevando a cabo el proyecto de investigación citado con varios estudios longitudinales en diferentes centros y comunidades autónomas.

Por lo demás, parece claro que integrar la creatividad en las metodologías de enseñanza puede ofrecer una conexión más sólida entre el aprendizaje conceptual y las aplicaciones del mundo real. Esto es especialmente importante para el caso de las materias STEM. No es nada complicado que el profesorado pueda proporcionar ejemplos concretos de comportamientos divergentes y creativos de genios creativos (científicos, pero también emprendedores), que los

estudiantes podrían emular (Jonas y Chambers, 2017). Y este plan también reconoce la utilidad de la IA como recurso didáctico, que abre todo un abanico de nuevas posibilidades para fomentar la creatividad (Miao y Holmes, 2023). Este es una línea de investigación especialmente interesante, en la cual esta doctoranda, arropada por el proyecto, ya está trabajando.

Pero no sucederá nada de esto si no se apuesta por un clima de aula donde arriesgar, equivocarse y salirse de la norma no estén fiscalizados; donde la cooperación entre compañeros no sea una práctica cotidiana; o donde los profesores no enseñen soluciones, sino reten a los estudiantes a buscarlas (las que existen y las que todavía no se han propuesto). En fin, un verdadero cambio de paradigma, según se apuntaba, que desde la reflexión teórico-metodológica que vienen impulsando las Didácticas Específicas casa perfectamente con el aprendizaje basado en problemas/proyectos/fenómenos, el aprendizaje cooperativo o, en fin, el aprendizaje significativo, que son sintagmas que definen enfoques educativos como la educación científica, educación ambiental, educación lingüística o educación literaria.

Esperemos que verdaderamente la creatividad sea la competencia del siglo XXI, como se repite en los debates educativos. Para ello, conviene puntualizar técnicamente qué es la creatividad, demostrar (o incluso denunciar) que no se atiende/entiende suficientemente en las aulas de Educación Secundaria, y que los investigadores y docentes debemos aceptar el desafío de solucionarlo con ciencia y creatividad.

Capítulo 8

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Anexo I

Artículos del Compendio

Primer Artículo

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THE TURNING POINT: SCIENTIFIC CREATIVITY ASSESSMENT AND ITS RELATIONSHIP WITH OTHER CREATIVE DOMAINS IN FIRST YEAR SECONDARY STUDENTS

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ABSTRACT

Research on creativity, as well as its application to the education field and its assessment at the different educational stages, have been of increasing interest over the past decades in different countries. In this context, this study aims to evaluate performance in scientific creativity and its relationship with other creativity domains (linguistic and general creativity) of Spanish first-year secondary students. This is a key moment both from the point of view of the change in educational level and a critical age in cognitive developments associated with creativity. The research was carried out using a quantitative, descriptive, cross-sectional design. Data was collected using previously validated tests. Results revealed a moderate-to-low performance for the scientific domain, as well as for the linguistic one and for general creativity. In addition, positive correlations have been found between all the studied domains of creativity. Nevertheless, this correlation was stronger between both scientific creativity dimensions (daily and specific). This research shows the scarce creative competence of students at the early stage of secondary education and gives evidence about the multicomponent nature of creativity. The need for the inclusion of creative teaching strategies at the secondary education level via transdisciplinary approaches is discussed.

Keywords: creativity domains; scientific creativity; secondary education

INTRODUCTION

Among the 21st-century skills (those needed to prepare students to succeed in their careers during the information age) are a solid education in science and the need for creativity and innovation (Kennedy & Sundberg, 2020). In fact, creativity has recently been put at the forefront of the educational research agenda. Therefore, an increasing number of countries have embedded this topic in their educational policies, including several countries that form part of the European Union (Austria, Belgium, Czech Republic, France, Portugal, Spain, among others), as well as Australia, China, England, the United States and Taiwan, for instance (Pllana, 2019; Patston et al., 2021).

Education fosters creativity by means of reinforcing acquired knowledge, cognitive skills, willingness to new experiences, and collaboration. Moreover, creativity has been associated with problem-solving, communication and metacognitive skills, which may enable not only academic and professional achievements, but also it may meet student's needs in their daily life (Batey & Furnham, 2006). Therefore, creativity has a key role in education, which has been grounded by the development of regulatory policies and assessment methods.

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Research on creativity and education may be divided into four large categories. The first one is focused on personality traits that may hinder or foster creativity, such as conformism or resilience. The second one falls into the cognitive area and addresses those factors affecting the creative process, for instance, intelligence or problem-solving abilities. The third one puts emphasis not on students, but on the educational system. Therefore, it tackles the analysis of curricula and initiatives to develop creativity. The last approach falls into a much more sociopsychological area, investigating the relationship between experience, behavior, environment, and students' creativity.

Since all of these categories explore the potential links between creativity and specific concerns, scholars resort to several techniques in order to assess students' creativity. This includes methods ranging from self-report questionnaires (Jonason et al., 2017), divergent thinking tests (Runco et al., 2016), and personality tests (Puryear et al., 2017), to more specific assessments centered on concrete domains by means of different settings (Lemons, 2011; Said-Metwaly et al., 2017). Given the substantial accumulation of assessment approaches, researchers are often involved in controversial debates. The key concern nowadays deals with the lack of an established conceptual and methodological framework, which leads to a vast quantity of scattered literature analyzing some creative processes and phenomena in an isolated manner.

To overcome this limitation, reviews have been published compiling creativity assessments in a large variety of settings (Snyder et al., 2019; Karwowski et al., 2019; Acar & Runco, 2019). Furthermore, there are other reviews pointing to the imperative need of achieving accuracy, homogenization, and transparency of the reported creativity results, which may lead to the refinement of research and assessment methods in creativity (Barbot et al., 2019). Those define a series of guidelines, such as providing transparent evidence of data selection and analysis, properly applying statistical tests according to the given sample, and interpreting results in terms of a well-defined creativity construct (Barbot & Said-Metwaly, 2021). Regarding the latter guideline, there is still little consensus in the field about which creativity construct to follow.

In this context, the existence of domains and their role in creativity performance have been hot topics of discussion since the early stages of formal creativity research. Aiming to get insight into the domain specificity of creativity, Baer and Kaufman (2005) proposed the Amusement Park Theoretical (APT) model, which includes both general and domain elements. The structure of the model is hierarchically established using four levels: initial requirements, such as intelligence or motivation; thematic areas, regarding different knowledge disciplines; domains, related to specific areas within those disciplines; and microdomains, corresponding to concrete tasks within those domains. Although the APT model is considered to present some limitations, there is a widespread consensus on the multicomponent nature of the creativity construct (Barbot et al., 2019).

In the literature, there are different studies focusing on a certain creativity domain. Some embrace a linguistic approach, such as metaphor generation, since it is considered to be an explicit manifestation of creative thinking (Bergs, 2019). Other domains, such as art, mathematics or music, are also analyzed in several studies (Erbas & Bas, 2015; Mansour, 2018; Kladder & Lee, 2019).

Regarding scientific creativity, it has been addressed by means of specific scientific productions or problem-solving patterns (Chen et al., 2016; de Vries & Lubart, 2019). In fact, a comprehensive meta-analysis of empirical studies examining the domains of creativity supports the idea of the existence of a mathematical/scientific domain that is consistently distinct from other domains of creativity (Julmi & Scherm, 2016). The existence of a particular scientific domain in creativity is not surprising, since the role of creativity in the processes of generation of knowledge in science is evident, with many similarities between the creative process and the scientific method (Garcés, 2018). Science can foster creativity and creativity should be an essential component of science in school (Antink-Meyer & Lederman, 2013). Ramdani et al. (2022) point to creativity and curiosity as important variables to support the performance of outstanding science teachers. The influence of aspects such as motivation (Xue et al., 2018), attitudes (Nursiwan & Hanri, 2023), science process skills (Fadlan et al., 2019), and emotions (Feist, 2015) in scientific creativity has been studied. There are some studies showing a positive correlation between scientific and mathematic creativities (Huang et al., 2017). However, to the best of our knowledge, no study has previously addressed the relationship between the scientific and linguistic domains of creativity.

In recent years, the comparison among different creativity domains has attracted a lot of interest, and even more so, their relationship with a general creativity construct, which commonly

is wrongly associated exclusively with divergent thinking tests (Baer, 2015). However, those approaches are thought to lead to contradictory results (Kaufman et al., 2017). Therefore, researcher-sought to embrace a much more holistic approach, assessing multiple domains of creativity, by means of a more accurate analysis design (Long et al., 2022), as is performed in this research.

To fill this gap and to gain more insight into the Spanish secondary education context, this study aims to assess a key area of creativity, as is the scientific domain, and study its relationship with other creativity domains in first-year secondary students. This is a turning point since it corresponds to the change between primary education and secondary education (where educational methodologies usually change with the introduction of scientific disciplines and the progressive abandonment of project-based learning). This is also a key stage in the development of creativity, since there is a discontinuity between creative potential in childhood and adolescence, with each stage associated with distinct developmental conditions and pathways, as well as biological and psychosocial changes. This has been confirmed by neuroscientific evidence of the decrease of gray matter during adolescence (Raznahan et al., 2010) leading to the observed creative cognition slumps and the decrease of divergent thinking in this developmental stage (Lau & Cheung, 2010). A recent meta-analysis (Said-Metwaly et al., 2021) positions this slump in seventh grade, in ages 12-13, the target population of this study.

In this context, the main objective of the present study is to assess the scientific creativity of first-year secondary students and explore its correlation with other creative domains (linguistic creativity and general creativity), as this has not been done before. The research questions were as follows: a) What is the scientific creativity level of first-year secondary students? b) What is their performance in linguistic creativity and general creativity? d) Are there differences in terms of gender? d) Is there a correlation between the scientific and linguistic domains of creativity? And between those domains and general creativity?

METHODS

This study utilized a quantitative, descriptive, cross-sectional research design. Participants were 226 first-year secondary students from three different Spanish high schools, from both rural and urban areas located in eastern Spain. There was gender homogeneity among the participants with 47% male students and 53% female students. The age of participants ranged from 11 to 14 years old, with an average age of 12 years old, which is the typical age of students at this level in Spain. As mentioned above, this is a key stage in the development of creativity, coinciding with the discontinuity between creative potential in childhood and adolescence.

Data was collected during the 2022-2023 academic year (in paper-based questionnaires) in 50 minutes sessions for every class group. Prior to the sessions, school management teams, legal guardians, and participants were informed about the treatment of the data and the scope of the research. Three previously reported and validated instruments were used to assess scientific creativity, linguistic creativity, and general creativity.

a) The scientific creativity dimension was assessed using a problem-setting up questionnaire developed by Hu et al. (2010), which is based on the Torrance model of creativity, and is described by the authors as robust and reliable (with inter-rater reliabilities between .69 and .85). Therefore, problem finding creativity was assessed in terms of fluency (how many ideas), flexibility (variety of fields corresponding to those ideas) and originality (statistical frequency of those ideas at the analyzed sample). This instrument includes two items. The first one aimed to assess the daily scientific creativity (DSC) consists of an open instruction, in which students are asked to write as many and different questions as they can related to science and based on their everyday life experiences. The second item aimed to assess the specific scientific creativity (SSC) corresponds to a closed instruction. Participants ought to create scientific questions associated with the image of an astronaut standing on the moon, and, therefore, this item captures more specific scientific knowledge, which yields the formulation of creative questions. Items were presented to students as PowerPoint slides and the time to generate questions was limited to 8 minutes per item. As mentioned above, the scoring was three-folded: the fluency score is associated with the number of valid questions generated, the flexibility score corresponds to the fields in which those are categorized, and the originality score is related to the statistical appearance frequency of a given question. DSC and SSC scores were calculated as the sum of these three values.

The different categories for each questionnaire are presented in Tables 1 and 2.

Table 1. Codification of Flexibility Categories Corresponding to DSC

Code	Field of Knowledge
ANT	Anthropology (evolution)
AST	Astronomy
BIO	Biology (plants, animals, genetics)
SCIE	Science Spirituality and Feelings
CON	Constructions and Transport
COV	COVID
PHY	Physics
GEO	Geology (meteorology, earth composition)
HUM	Human Body, Health
PRO	Products properties and their usage
CHEM	Chemistry (materials properties and reactions)
TEC	Technology

As can be seen, there were 12 different categories for daily scientific creativity and 7 different categories for specific scientific creativity.

Table 2. Codification of Flexibility Categories Corresponding to SSC

Code	Field of Knowledge
AST	Astronomy in general
EXT	Extraterrestrial life
PHY	Physics (gravity, space traveling)
MOO	Moon's Composition and Meteorology
LIG	Sunlight, darkness, and looking at the moon
TEC	Technology and Communications
LIF	Daily life of astronauts on the moon

b) The linguistic creativity dimension was assessed in terms of a metaphor generation task, based on the work of Kasirer and Mashal (2018), which distinguishes between novel creative metaphors from conventional ones. The instrument includes 10 items. Whereas each of them corresponds to an emotion, half of them were presented in order to yield a metaphor (e.g., love is…) and the other half were presented aiming to promote an analogy formulation (e.g., sadness is like…). Students ought to generate a novel figurative expression, avoiding the use of synonyms or commonly used metaphors. The time provided to answer was limited to 8 minutes in total. The scores given were 1, 2 or 3 points, for literal responses, conventional figurative expressions, and novel metaphors, respectively. The linguistic creativity was calculated as the sum of all the obtained points. Two judges coded the data independently, with an agreement rate of 90%. Any case of disagreement was discussed by both coders. c) General creativity was addressed using a previously validated questionnaire widely used in the Spanish educational context, which is known as CREA. In this case, students ought to generate as many questions as they can pertaining towhat is happening at an image. Hence, several cognitive schemes are tapped into, arising from the interaction between the new mental representation of the image, and their already existent mental network of representations. The time established for the test is 4 minutes. This test has been found to have both predictive and concurrent validity (as measured in concurrence with the Guilford test of creativity) (Corbalán et al., 2015). Prior to assigning the corresponding scores, out-of-context questions or repetitive questions were invalidated. Each simple question is awarded 1 point, whereas double or triple questions (which reflect two or three different phenomena or actions) are ranked as 2 and 3 points, respectively. The percentile index is extracted afterward from the CREA Manual (Corbalán et al., 2015) for a Spanish sample.

The statistical analysis of the compiled data was performed using SPSS software version 26. Firstly, the mean and standard deviation for each of the studied dimensions of creativity was calculated. To get insight into the normality of the data, the Kolmogorov-Smirnov test was carried out. Since all variables presented non-normal distributions, differences according to gender were explored using the Mann-Whitney U test. The effect size was calculated using the formula described by Field (2018) for non-parametric samples. The magnitude of the effect size was evaluated according to Cohen's classification for behavioral sciences (1988), being null if $0 \leq |g| \leq .1$; low $.1 < |g| \leq .29$; medium $.30 < |g| \leq .49$ and large if $.5 \leq |g|$. Finally, the correlation among the studied creativity dimensions and the general creativity was evaluated by means of the Pearson's correlation coefficient. In all cases the significance level was .05.

RESULTS AND DISCUSSION

The main aim of this study was to assess the scientific creativity of students at the beginning of secondary education. The results associated with both scientific dimensions of creativity (DSC and SSC) are shown in Table 3. This table also includes the scores of the three evaluated properties (fluency, flexibility, and originality).

Table 3. Descriptive Statistics for both Scientific Dimensions of Creativity

Creativity dimension		Mean	SD
DSC	Fluency	8.63	4.78
	Flexibility	4.57	1.87
	Originality	0.75	1.15
	Total	13.96	6.70
SSC	Fluency	9.20	4.67
	Flexibility	4.26	1.30
	Originality	0.31	0.67
	Total	13.73	5.91

As can be observed in Table 3, fluency scored around 9 for both studied dimensions, meaning each student have formulated 9 questions approximately. Indeed, it has been detected that students tend to formulate many similar questions in their questionnaire answers. As an example, in the case of the daily-scientific dimension, students lay down a multitude of queries about the Universe and astronomy, such as: "Why does the sun rise in the morning and why does the moon come out at night?"; "Why is the Universe infinite?"; "Is there extraterrestrial life?". On the other hand, for the specific-scientific dimension, questions formulated by students tend to be related to the composition of the moon, its morphology, and the possible existence of air, oxygen, and an atmosphere, e.g.: "Is there oxygen on the moon?"; "Why is the flag waving if there is no air on the moon?"; "Why are there craters on the moon?"; "Why is the moon grey?".

Regarding flexibility, its score is roughly 4 for both dimensions of scientific creativity, meaning students use approximately 4 different knowledge fields to formulate an average of 9 questions. Figures 1 and 2 represent the number of questions per category for DSC and SSC, respectively.

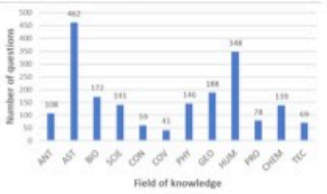

Figure 1. Number of Questions Formulated by Students, Corresponding to Each Field of Knowledge for DSC

It can be observed that the fields that show a higher count are "Astronomy" and "Human body/Health" for DSC and "Moon's composition and Meteorology" and "Technology and Communications" for SSC.

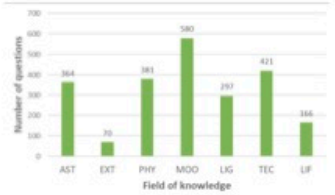

Figure 2. Number of Questions Formulated by Students, Corresponding to Each Field of Knowledge for SSC

Concerning the originality score, it hardly reaches 1 for both investigated scientific dimensions of creativity. In other words, barely one of the averaged 9 questions formulated by students was unusual or unique (with a percentage of appearance frequency lower than 5%). DSC original queries were very varied, for instance: "How is paint made?"; "What is the operating mechanism of a microwave?"; "Why do we have to age?"; "Why do we feel pain?". Note that almost all the original questions pertain to daily actions or phenomena related to everyday life. In the case of SSC, some original questions formulated by students were as follows: "Why is there a hidden face of the moon?"; "If we were to reach a gaseous planet, would we fall into its nucleus?"; "Are earthquakes possible on the moon?"; "Do diseases exist in space?". These results are similar to those reported by Hu et al. (2010). Particularly, the ability to come up with new ideas (originality) and the overall scientific creativity performance tends to be limited. Students generally use the same fields of knowledge to formulate questions (low flexibility), such as Astronomy and Health (DSC), and Technology and Physics (SSC). Moreover, queries are often non-related to students' experiences and inquietudes, and tend to reflect a decontextualized conception of science as an abstract and complex discipline.

On the other hand, the results corresponding to the linguistic dimension of creativity with the different metaphor categories are shown in Table 4.

Table 4. Descriptive Statistics for the Linguistic Dimension of Creativity

Creativity domain		Mean	SD
Linguistic	Novel metaphor	0.95	1.62
	Conv. metaphor	1.42	1.43
	Literal response	5.53	2.99
	Invalid response	3.04	2.60
	Total	11.23	5.26

As can be observed, "novel metaphors" is the category with fewer responses. Indeed, barely one of each student's responses falls into this category. As for conventional metaphors, students come up with a mean of one to two of them in their responses. However, the literal answers are those prevailing over all the other categories, since students tend to give examples of how they feel instead of creating novel metaphors or thinking about preexisting ones. Within this category, typical teenage feelings have been identified, such as friendship, loneliness, or body-image insecurities. Additionally, comparisons regarding academic issues are recurrent, as well as analogies with video games, football teams and players. Finally, a large amount of students' responses were invalid, since they were blank or reflected an erroneous concept.

Analogously to what happened for scientific creativity, linguistic creativity results indicate a moderate to low performance. This latter observation is similar to the one reported by Kasirer

and Mashal (2018), and their capacity to generate novel metaphors is lower than the one obtained by Kasirer and Mashal (2016) with typically developed Hebrew-speaking adolescents. Specifically, students tend to generate analogies closer to their experiences, rather than create novel and unique metaphors. It is important to consider that at this educational stage, students are not able to fully understand the concept of a metaphor, and therefore, they commonly approach this creativity task using already existing mental representations, regarding their own experiences and observations (Carriedo et al., 2016). In addition, those participants that generate novel metaphors usually use similar stylistic devices, such as personification or apostrophe, and comparisons with some meteorological phenomena.

Finally, in the CREA test for the assessment of general creativity students formulated an average of approximately 11 queries about the image shown, and the number of extra questions (double or triple) was scarce. They obtained a total mean value of 11.2 ± 5.26. Results were much lower than those obtained by Donadel et al. (2021) for an adolescent Argentinian sample, although in their case there were also older (up to 16 years old) students. Most asked questions were related to the feelings of the characters in the image, their ages, their appearance, their clothing, and their occupations, as well as the location of the image. Regarding the percentile, it was 39%, below the median value, meaning that the general creativity was moderate-to-low. This reflects that students at this educational stage possess a scarce level of creativity, being below the median percentile. Note that the test used in this study is based on a question formulation process throughout the visualization of an image. Therefore, this test reflects the openness and versatility of the cognitive schemes of students, which results in the reorganization and interconnection of different mental representations. Authors of the test suggest that this behavior may result in a potential ability to develop creative competences (Corbalán et al., 2015).

Table 5. Descriptive Statistics for the Studied Dimensions of Creativity According to Gender (N_{male}=107; N_{female}=119).

Dimension	Gender	Min	Max	Mean	SD	z	p	g
DSC	M	2	33	13.07	6.28	1.748	0.082	-
	F	3	37	14.75	6.98			
SSC	M	0	28	12.28	5.81	3.393	<.001***	.226
	F	4	31	15.03	5.73			
Linguistic	M	0	29	10.27	5.45	3.280	.001***	.218
	F	1	29	12.10	4.95			
General	M	1	97	30.60	27.83	4.439	<.001***	.295
	F	1	98	47.56	28.91			

*** There are statistically significant differences at the .001 level.

Once a general overview of the creativity performance was obtained, the possible existence of gender differences in all the creativity dimensions was investigated, since not many studies address gender performance in specific creativity dimensions. Table 5 shows data according to gender (the data for general creativity is given as the percentile index).

As can be observed, scores corresponding to female participants are higher in all studied creativity dimensions. Particularly those associated to SSC and general creativity, both of which are remarkably higher. As all the dimensions presented non-normal distributions, the Mann-Whitney U test was applied to gain an insight into the existence of statistically significant differences. The results indicate that all the evaluated dimensions of creativity display statistically significant differences between genders, with the exception of DSC. The size effect was low for SSC and linguistic creativity, and medium for general creativity. These findings are in concordance with those reported for prior studies in general creativity (Nakano et al., 2021). Generally, females are regarded as creative beings, especially in arts and performance domains (Kaufman, 2006; Elisondo, et al., 2022; Pont-Niclos et al., 2022), and not particularly in scientific or technical domains. However, these results show that gender stereotypes are not always accurate.

Finally, to explore the possible existence of any correlation between scientific creativity and the other studied dimensions of creativity, Pearson's correlation coefficients were calculated (see Table 6). As can be observed, there is a positive and significant correlation in all cases.

This means that those students performing in a particular manner at a concrete dimension of creativity display an analogous behavior at the other dimensions. It is worth noting that there is a higher correlation between both scientific dimensions of creativity (DSC and SSC) than between those two found in the linguistic dimension. The highest correlation with the general measurement of creativity is with SSC.

Table 6. Pearson's Correlation Coefficient between the Studied Creativity Dimensions

	DSC	SSC	Ling.	General
DSC	1	.66***	.49***	.54***
SSC		1	.49***	.64***
Ling.			1	.45***
General				1

*** There are significant correlations at the .001 level

Since the correlation between scientific creativity with other creative dimensions had not been previously studied, only with mathematical creativity (Huang et al., 2017), this fact could be misinterpreted as a point corroborating the general construct of creativity, whose validation has a leading role at the debates within this field (Baer, 2015; Snyder et al., 2019). On one hand, students who show a concrete creativity performance at one dimension, typically show the same efficiency at others. On the other hand, it must be taken into account that the strongest correlation has been detected between both studied scientific creativity dimensions (DSC and SSC), rather than those and the linguistic. Moreover, results point out that the assessment procedure influences students' performance, since the highest correlation was found between SSC and the general creativity measurement, and both tests are based on the idea of formulating questions on what is happening in an image. Regarding this fact, several studies have shown that different modes of thinking involved in different types of creative work are accompanied by different patterns when it comes to brain activity (Kleibeuker et al., 2013).

At this point, it is important to consider different approaches that can contribute to the development of creativity in science. Although domain knowledge is important in scientific creativity (Sun et al., 2020), teaching styles must encourage students to come up with new and unusual ideas in a respectful environment. This is something pedagogically irrefutable, but not the norm in the Spanish educational system.

On the other hand, different approaches such as problem or project-based learning seem a good starting point since they are believed to promote many processes related to creative thinking (Anazifa & Djukri, 2017; Rasul et al., 2018; Sumarmi & Kadarwati, 2020). This type of methodology is perfectly aligned with the STSE (Science-Technology-Society-Environment) approach. Also, establishing rewards and promoting self-fulfillment can be used to enhance students' motivation, particularly the intrinsic one (Begettho & Kaufman, 2014), as well as the use of gamification strategies in science classes (Funa et al., 2021). Moreover, teachers should facilitate creative examples, which students will be able to emulate. Indeed, creativity emulation is an emergent research area (Cotter et al., 2022) focused on how the creativity of students can be fostered via teachers' recreation of creativity performance.

Finally, several studies have assessed the creativity demonstrated by preservice primary education and chemistry teachers (Echegoyen & Martín-Ezpeleta, 2021; Martín-Ezpeleta et al., 2022; Apriwanda & Hanri, 2022) with discouraging results. Connected to the above, they should promote a reflection on the process, in the form of a metacognitive reflection. Metacognition processes play a key role in creativity capabilities since they deal with the self-efficacy concept and the proper contextualization of creative actions. Therefore, teachers should incorporate actions at their lessons including different metacognition mechanisms in order to promote the development of creativity (Kaufman & Beghetto, 2013).

CONCLUSION

The main aim of this work was to assess the scientific creativity of first-year secondary students and evaluate their correlation with different creative domains. The results obtained pointed out the scarce creative competence of students at the early stage of secondary education in all three dimensions studied. Although there were correlations between all creative dimensions assessed, those were higher between both kinds of scientific creativity (daily and specific) than between scientific creativity and other creative domains. This points out the multicomponent nature of the creativity construct. In addition, gender diffe-

rences in creativity performance have been obtained for all creative dimensions, with female students demonstrating higher creativity scores in all cases. Nevertheless, first, some limitations need to be pointed out. Only one grade of secondary education has been assessed and the instruments used, although validated, could have their limitations. Future studies will focus on larger and even more delocalized samples. It would also be very interesting to corroborate this low level of creativity in science with longitudinal studies of all levels of secondary education. In spite of these limitations, our results lead us to conclude the importance of rethinking the development of creativity in the educational system. As discussed in the previous section, there should be a reorientation of the curricula and teaching methodologies in science lessons, as well as in other subjects. Certainly, different teaching concerns such as the above-mentioned problem-solving, critical, and divergent thinking are transversal key points in education. Accordingly, it is essential to raise awareness among educational professionals about these considerations, as well as to design didactic resources within each subject, which will enable the fostering of creativity as a collective educational aim. Although some of those factors have been considered recently in the educational agenda, they are not always present in secondary education classrooms in Spain and, particularly, not in science lessons. The present research shows that students' mediocre results should lead to a response in the form of innovative educational designs giving creativity the space it deserves.

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Article

Assessing the Linguistic Creativity Domain of Last-Year Compulsory Secondary School Students

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Abstract: The importance of creativity in the training of people gained special relevance with the PISA Tests of the OECD, which, for the first time, evaluated the general creativity of 15-year-old students in 2022. This descriptive and quantitative study focuses on the evaluation of linguistic creativity, using different classical instruments to measure divergent thinking and adding new ones, such as metaphorical capacity. Participants were 454 students in their last year of secondary education from eight Spanish educational centers. Results indicate moderate performance in divergent thinking tasks, with students exhibiting limitations in generating novel metaphors, often resorting to literal responses. Statistically significant differences according to gender were found in metaphor generation and in the alternate uses task. A correlation study reveals significant associations between metaphor generation and divergent thinking tasks. These highlight the differential role of semantic memory and cognitive processes involved in metaphor generation and divergent thinking. Finally, this study underlines the complexities and multicomponent nature of creativity as a first step to develop educational policies and interventions targeting creativity. Overall, the importance of addressing creativity in a transdisciplinary way and training teachers on techniques to channel creativity are highlighted, such as through the design of challenges or writing workshops.

Keywords: creativity; linguistic creativity; divergent thinking; competence assessment; secondary education; Spanish educational system

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1. Introduction

1.1. Creativity and Its Role in Education

Creativity, as a broad concept embracing much more than artistic endeavors, has sparked lively research regarding its role within many social areas, such as the workplace or education. Indeed, creativity is considered a key 21st century skill that allows future citizens to cope with an uncertain future [1]. Nevertheless, the creativity construct has been nourished by multitude of socio-cultural and historical contexts. Hence, its conceptualization has been modified, shaped and reframed over long periods of time [2].

Despite the existence of many definitions of creativity, most of them share two essential characteristics: novelty and usefulness [3]. The former term is associated with newness or uniqueness, and the latter is related to meaningfulness or appropriateness [4]. In addition, researchers agree on the multi-componential nature of creativity [5].

Indeed, the existence of creativity domains has been extensively discussed since the early stages of this research field [6]. In recent years, a consensus has grown acknowledging the multi-componential nature of creativity, compiling both domain-specific and general features and also including social and cultural connections [7,8]. Moreover, some neuroimaging studies lean into this argument, offering supporting evidence that highlights the multifaceted character of creativity [9,10]. From a theoretical point of view, the well-known Amusement Park Theory (APT) states that there are four hierarchical stages that allow

creative processes to occur, coming from initial requirements that must be present, such as a supportive environment or a basic level of intelligence and interest, followed by knowledge in general thematic areas, such as science or arts, and arriving at specific domains and microdomains, which correspond to concrete sub-themes and tasks [2,11].

Several theoretical and empirical proposals, rooted in different psychological perspectives, analyze the componential nature of creativity. On the one hand, personality traits of creative individuals have been examined by means of a vast quantity of research instruments [12], ranging from general personality tests to repertoires of specific creative factors. These studies pointed out the existence of certain personality traits, closely related to creativity [13]. Considering "The Big Five" personality model [14], these traits mainly correspond to the openness dimension [12,15]. On the other hand, the mechanisms involved in creative performance are also widely addressed in the literature. In this context, it is essential to define the item to be studied, which may be identified applying the "Four P" (person, process, product and press) model [16] or the more recent "Four C model" [17] with four levels of creative completion: "Big-C", "Pro-C", "little-C" and "mini-C". This latter model amalgamates all the creativity manifestations during the learning process. Hence, nowadays, creativity and learning are thought to be processes working side by side, reinforcing each other by means of the interactions among the students, the community and the cultural context [18].

Therefore, schools are considered the perfect arena to develop the creative abilities of students to meet not only personal and professional, but also social needs [19]. By providing access to diverse perspectives, knowledge and experiences, education plays a crucial role in developing creativity in conjunction with other essential skills, such as communication, teamwork and adaptability. There is even a relationship between creativity and academic performance [20]. This is the reason why several international programs and initiatives, as well as national government policies, have placed creativity training at the forefront of the educational agenda [20]. This is the case of Spain, whose recent educational law [21] highlights that "creativity will be worked on in all subjects". Lacking the release of the results of the PISA 2022 tests on general creativity, the few studies carried out for the Spanish population (most of them in primary education and now leaving those dedicated to the diagnosis of high-capacity students) show a low development into the secondary education stage.

1.2. Towards Creativity Assessment Instruments: Which Facet of Creativity Is Evaluated?

Based on this complex paradigm, there are several research lines regarding creativity in education, such as the study of the influence of personality traits, cognitive factors or education programs on creative processes, most of which are based on the assessment of creativity, by means of a wide range of instruments and settings [22,23]. Those assessment techniques may be classified into three major approaches: measuring creativity accomplishment, based on product generation; studying individual profiles and characteristics, which lead to creativity potential (cognitive abilities, personality, motivation, emotional characteristics and environmental traits); and the evaluation of creativity potential by means of predefined tasks [1].

The abundance of assessment approaches has sparked controversial debates among researchers since this fragmentation of settings may hinder the development of a comprehensive understanding of creativity and its underlying mechanisms. Hence, reviews have been published aiming to consolidate the existing knowledge and provide a comprehensive overview of the different approaches used to assess creativity [24–27]. In addition to the compilation of assessments, there is a growing recognition of the need for accuracy, homogenization and transparency in reporting creativity results [5]. Achieving these standards is crucial in advancing the field of creativity research, even though the complexity and multidimensional character of creativity still leave room for the improvement and consolidation of its understanding [28].

However, among all of these scattered assessment techniques, the conceptualization that Guilford stated in 1950 prevails [6], mainly because divergent thinking tests are still the most extensively used to evaluate creativity [29]. Indeed, it is considered that divergent thinking focuses on generating multiple ideas envisioning numerous potential answers to a task, problem or question, whereas convergent thinking involves finding the most appropriate answer to that particular task, question or problem [30].

Despite this fact, the assumption that divergent thinking necessarily represents creativity has faced dispute [31]. Researchers are recently more prone to adopting a more comprehensive approach by evaluating creativity by means of multiple approaches. That implies not evaluating isolated creativity domains, but considering the relationships between them and exploring convergent and divergent thinking processes [32], as well as taking into account further key aspects that forge each individual's creativity profile [7]. By embracing this integrative perspective, researchers may underpin the complex nature of creativity.

1.3. Focusing on the Assessment of the Linguistic Domain of Creativity

Divergent thinking has been traditionally evaluated by open-ended prompts that ask us to think creatively [26]. In this context, the Torrance Test of Creative Thinking (TTCT) [33] and its derivatives have provided extensive evidence of their validity as creativity assessment instruments, shedding light on the correlation between general creative abilities and creative outcomes in different areas [34]. Among those divergent thinking tests, the Alternate Uses Task (AUT) has been the most widely used. It implies generating unusual or alternate uses of everyday objects, such as a brick, a box or a knife. This test holds a notable advantage in providing a solid indication of an individual's overall ability to generate original ideas. However, it is important to note that despite its strengths, the AUT does have some limitations [35,36]. Regarding the AUT test score as a ubiquitous measure of each and every creativity domain, either scientific, linguistic, performance or daily, may lead to the consideration of a test score as the exclusive indicator of one's creative potential [37,38], disregarding crucial differences between general and specific forms of creativity [39].

In this regard, there are numerous studies in the literature focused on specific areas of creativity [40], such as linguistic creativity, since languages are ought to be the vehicle to express creativity competency: "Language is a process of free creation; its laws and principles are fixed, but the manner in which the principles of generation are used is free and infinitely varied" [41]. Taking into account that linguistic creativity may also arise from not following the preestablished rules [42], there are different key points that directly influence this creativity domain, not fully conceptualized yet [43,44]. In this regard, the classic associative theory [45] states that creative processes involve establishing connections between apparently non-associated concepts. Some divergent thinking tasks based on this theory have shown encouraging reliability and validity in quantifying the semantic distance between words: words that usually appear in certain contexts are linked by a lower semantic distance, such as dog and cat, and this is related to low-creativity linguistic profiles [46]. One promising approach in this context is the application of computational methods in order to automate the scoring of semantic distance. For instance, the algorithm developed by Olson and collaborators [47] provides an effortless and open resource to assess creativity by naming unrelated words as a measure of divergent thinking.

Not only has linguistic creativity been considered in terms of semantic distance, but it has also been related to figurative language. In particular, the production of metaphors is a potential source of linguistic innovation, since they are considered the prototypical materialization of creative thinking [43,48]. In this context, the property attribution model states that the establishment of an abstract link (attributive category) is a requirement in order to reflect an unusual common characteristic between two apparently unrelated concepts [49]. In addition, semantic memory plays a key role allowing the retrieval of multiple elements, increasing the likelihood to create original

connections between those elements [50,51]. Furthermore, metalinguistic skills are also needed in pursuance of using figurative language in a creative manner [52]. Nevertheless, these skills are developed later on in adolescence, after the capacity for figurative expression comprehension. Indeed, the ability to understand metaphors is directly related to semantic and cognition maturation and follows a highly linear trend [53], whereas the ability to produce metaphors displays a "U" fashion, from childhood up to adolescence [54]. Regardless, the comprehension and application of figurative language are non-necessarily sequential processes and may occur simultaneously.

Taking all of the above stated into account, this study is focused on exploring the links between the creative production of metaphors and different divergent thinking tasks: the alternate uses task and the naming of unrelated words (semantic distance). Its aim is to add up evidence regarding the influence of semantic networks on creative tasks, as well as to obtain insight into the different mechanisms and correlations underlying linguistic creativity. The spotlight of this investigation is on Spanish students in their last year of compulsory secondary school (fourth grade: between 15 and 16 years old), since their linguistic competencies may be mature enough to face the proposed linguistic creative tasks. Furthermore, their creative skills may shed light on the adequacy of the Spanish education system to develop these skills. Specifically, the research questions that nurture this work are:

- What is the creative performance, in the linguistic domain, of Spanish students in their last year of compulsory secondary school?
- Are there any differences according to the gender of students?
- Are the three linguistic creativity tasks (metaphor generation, naming unrelated words and alternate uses task) correlated?

2. Methodology

2.1. Participants

A total of 454 Spanish students in their last year of compulsory secondary education participated in this research. Data were collected during the 2021–2022 academic year at eight different Spanish high school centers, from both rural and urban areas located in eastern Spain. There was gender homogeneity among the participants, with 49% male students and 51% female students (no participant marked the "other" category). The age of participants ranged from 14 to 17 years old, with the average age being 15 years old (mean 15.3, standard deviation 0.6), which is the typical age of students corresponding to this level in Spain. All students, teachers and legal tutors were thoroughly informed about the protocols and the aims of the investigation and agreed to participate. In this regard, the agreement documents provided by the Ethics Committee in Experimental Research of the University of Valencia were signed.

2.2. Instruments and Data Collection

Linguistic creativity was assessed by means of three different creativity tasks reported in previous studies: naming unrelated words, metaphor generation and the alternate uses task. In order to collect data, paper-based questionnaires were used, typically during 50 min of a standard class session in Spain. Both the teacher and a researcher were present while the tasks were completed by students. All the instructions for test completion were given by the researcher and a slide presentation with all the steps was shown.

The first creative task was the naming unrelated words task [47], where students were asked to generate 10 nouns (e.g., song) which are as different from each other as possible, in all meanings and uses of the words (e.g., song and ant). All words belonging to other syntactic categories were discarded (e.g., verbs as to sing or adjectives as beautiful) and only the first seven correct words were computed for each student. The scoring process was performed using a computational algorithm developed by the above-mentioned authors and available online [47]. The semantic distance between the words was evaluated from all 21 possible pairs of the seven words, taking the average and providing a percentage

value. Commonly, scores ranged from 75 to 80 and usually scores bellow 50 indicated a misunderstanding of the test directions, such as naming antonymous words (e.g., white and black). This score, evaluated by means of a semantic distance/divergent thinking task, has been proven to be related to the ability of formulating creative and remote associations.

The second creative task, the ability to generate metaphors, was assessed by means of an instrument developed by Levorato and Cacciari [52] and later adapted by Kasirer and Mashal [55]. Students were asked to ideate metaphors to describe a total of 10 items. Each of those items refers to a particular feeling or emotion, for instance happiness, sadness, euphoria or frustration. Five of the items were formulated in order to promote a figurative reformulation (e.g., love is . . .), whereas the remaining five were presented in the form of a simile (e.g., feeling worthless is like . . .). Prior to the scoring process, inappropriate answers (decontextualized or empty) were discarded and then answers were classified into three categories: novel metaphors, which are unique and original (3 points); conventional metaphors, which are used commonly as an expression or idiom (2 points); and literal responses, which are merely descriptions or analogies without figurative meaning (1 point). All generated metaphors were evaluated by two researchers (one of them a philologist). The interrater reliability was superior at 85%. Those items with discrepancies were discussed by both researchers until they reached a consensus.

Finally, the alternate uses task was carried out by means of the PIC-J test [56,57], which is an adaptation of the TTCT [33], with high validity and reliability in Spanish students. This test assesses divergent thinking skills and the results are associated with the ability to produce multiple ideas and associations. Students were asked to come up with alternative uses for a rubber tube, considering any size and shape valid and even interconnections between different tubes. The scoring procedure is based on the conception of creativity described by Guildford [6], which establishes three categories: fluency, as the number of valid responses; flexibility, as the number of different areas or themes used to formulate the totality of responses; and originality, as the number of unique and unusual responses. A total of 36 particular areas were used in order to compute the flexibility of the students' responses, classified into four degrees of novelty (e.g., blow/sip, 0 points of originality; scholarly uses, 1 point of originality; delivery, 2 points of originality; and lighting, 3 points of originality).

2.3. Data Analysis

The statistical analysis was carried out using SPSS software v28. Firstly, the mean and standard deviation for each of the studied creativity dimensions were calculated. Secondly, the Kolmogorov–Smirnov test was used to evaluate the normality of the distributions. Then, gender differences were investigated using either the Student's t-test for independent samples (normally distributed variables) or the Mann–Whitney U test (non-normally distributed variables). Finally, the correlation between variables was analyzed via Pearson's correlation. In all tests, the significance level was 0.05. The magnitude of the effect size was evaluated according to Cohen's classification for behavioral sciences [58] by calculating the Hedges's parameter g or alternatively applying the corresponding formula for non-parametric data when needed [59].

3. Results

3.1. Divergent Thinking Tasks and Creative Metaphor Generation Performance

The results corresponding to the creativity performance associated with each test are shown in Table 1. The values of creativity corresponding to the naming unrelated words task (M = 79.3; SD = 4.4) are considered moderate according to Olson and colleagues [47]. Nevertheless, this mean value lies on the upper level of the moderate interval, which may mean a slightly high ability of students to think divergently during their last level of compulsory education. In spite of that, the values corresponding to the metaphor generation task are, in general, low. This fact is directly related to the typology of responses produced by students, which are represented in Figure 1. As can be observed, a vast number of responses

are classified as literal (1 point) or invalid (0 points) responses. Therefore, students are not able to produce novel metaphors appropriately and they resort to analogies or examples, rather than figurative expressions that are either conventional or ideated by themselves.

Table 1. Descriptive statistics for each creativity task (N = 454).

Creativity Test	Min	Max	Mean	SD
Naming unrelated words	64.4	90.8	79.3	4.4
Metaphor generation *	1	25	11.2	4.6
Alternate Uses Task (Total) *	3	89	33.6	16.9
Alternate Uses Task (Fluidity) *	1	35	12.8	6.3
Alternate Uses Task (Flexibility) *	1	21	8.8	3.6
Alternate Uses Task (Originality) *	0	42	12.0	7.7

* Non-normally distributed variable; SD: standard deviation.

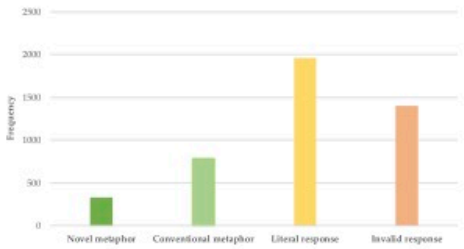

Figure 1. Classification of students' responses for the metaphor generation task.

A higher variability among students was found in the scores of the alternate uses task. As is the case for the naming unrelated words task, this test also assesses the divergent thinking abilities of students. However, a further analysis of the data reveals that even though the fluidity (number of responses of each student) is usually high, the originality and flexibility scores are limited. For instance, as can be observed in Figure 2, the uses for the rubber tube generated by students mainly lie in the same categories (e.g., scholarly uses, ninth category; conduction, second category; storage, fifth category; and personal accessories, fourth category), all associated with low originality profiles.

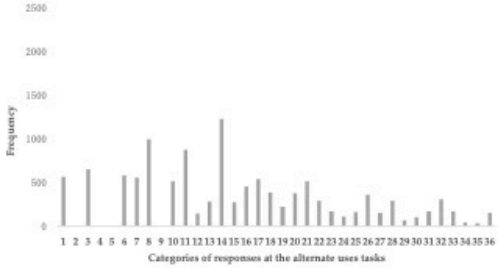

Figure 2. Classification of students' responses for the alternate uses task. From 1 to 7: 0 points of originality; from 8 to 18: 1 point of originality; from 19 to 24: 2 points of originality; from 25 to 36: 3 points of originality. A description for each category can be found in Appendix A (Table A1).

3.2. Differences According to Gender

Regarding gender differences pertaining to the different creativity tasks, female and male students scored differently, with an outstanding exception for the naming unrelated words task. As can be observed in Table 2, female students ranked more highly than male students for the metaphor generation and alternate uses tasks, whereas equivalent punctuations were obtained for both genders for the naming unrelated words task. Hence, the Student's t-test (normally distributed variable) and the Mann–Whitney U test (non-normally distributed variables) show only statistically significant differences according to gender for the latter mentioned tasks, both showing small size effects.

Table 2. Differences in creativity task performance according to gender.

Creativity Test	Gender	Mean	SD	z	*p*	g
Naming unrelated words	Female	79.08	4.17	0.94	0.34	-
	Male	79.51	4.71			
Metaphor generation *	Female	11.76	4.65	2.40	0.01 **	0.11
	Male	10.54	4.37			
Alternate Uses Task (Total) *	Female	36.75	17.07	3.60	<0.001 ***	0.17
	Male	30.37	16.10			

* Non-normally distributed variable; SD: standard deviation; **: There are statistically significant differences at the 0.01 level; ***: There are statistically significant differences at the 0.001 level.

3.3. Correlation between Divergent Thinking Tasks and Creative Metaphor Generation

In order to shed light on the possible correlation between the values obtained in the different creativity tasks, Pearson's correlation coefficients were calculated, and the results are compiled in Table 3. As can be observed, there are positive correlations among the scores of all the different creativity tasks, despite the low value of the correlation coefficient. However, significant correlations have only been found between the metaphor generation task and either the naming unrelated words ($p = 0.035$) or the alternate uses task ($p = 0.001$). Consequently, students who performed well in the generation of novel metaphors also managed to obtained good results when naming unrelated words and proposing alternative uses for the rubber tube. In spite of that, surprisingly, the performance in naming unrelated words does not correlate with the ability to come up with unconventional applications of an ordinary object (alternate uses task), even though both tasks have been extensively related to divergent thinking abilities [47].

Table 3. Pearson's correlation coefficient of creativity performance for different tasks.

Creativity Test	Naming Unrelated Words	Metaphor Generation	Alternate Uses Task
Naming unrelated words	1	0.0108 *	0.030
Metaphor generation *	0.108 *	1	0.351 **
Alternate Uses Task (Total) *	0.030	0.351 **	1

* Non-normally distributed variable; *: There are statistically significant differences at the 0.05 level; **: There are statistically significant differences at the 0.01 level.

4. Discussion

The current study explores the linguistic creativity of last-year compulsory secondary school Spanish students, by means of previously reported instruments mainly based on divergent thinking (naming unrelated words and alternate uses task), as well as metaphor generation. The data analysis revealed that students display moderate creative performance in the naming unrelated words task (within the typical interval between 75 and 80 [47]) and the alternate uses task (being the direct punctuation of the test, M = 33.6; SD = 16.9 [57]), whereas their performance in the metaphor generation test was lower than that reported by Kasirer and Mashal [55]. Indeed, the percentage of novel metaphors

was only 7% among all computed responses. These results are in line with a study by Pont-Niclòs and colleagues [60], which comparably assessed the scientific and linguistic creativity of first-year secondary school Spanish students. Similar to the findings reported in this work, the pattern of answers of students in the metaphor generation task was mainly associated with their already existing mental representations based on personal experiences and observations. This may be an early stage prior to being able to come up with novel metaphors, since metaphor comprehension and generation have been found to share common brain region activations, even though further research in this field is needed [61,62].

Regarding the influence of gender on linguistic creativity performance, no differences were found in the naming unrelated words task. However, statistically significant differences were obtained for the metaphor generation and alternate uses tasks, with girls scoring higher than boys in both cases. In this context, it must be noted that the impact of gender on creativity is not fully understood, although researchers agree that females and males differ in their cognitive strategies and brain functional task sets when engaging in creativity processes [63,64], which may lead to mixed and inconclusive findings regarding the relationship between gender and creativity. In spite of that, the results herein reported for the naming unrelated words task are in consonance with those described by the authors of the assessing instrument, who found no differences among genders [47]. Regarding the differences found in the metaphor generation and alternate uses task, they may be associated with multiple factors, such as cognitive abilities, preferences or stereotypical factors, which may favor engagement with the task [65–67]. In the case of the metaphor generation task, equivalent differences among genders were found for first-year secondary school Spanish students [60], whereas for the alternate uses tasks, studies using the instrument herein reported reached contrary results [57,68].

The correlation between the three different tasks assessing creativity has also been explored. Two of the tasks are mainly related to divergent thinking (naming unrelated words and alternate uses tasks), while the other includes broader creative processes (metaphor generation task). These sorts of correlations have sparked much debate, since they are related to the general/domain-specificity nature of creativity and the processes implicated at creation [69,70]. Indeed, multiple recent studies have examined neuronal activity during the completion of creativity tests, aiming to shed light on the underlying mechanisms of creativity production at different domains and their possible common patterns.

Regarding metaphor generation, findings suggest the significance of both verbal knowledge and working memory functions in understanding and creating metaphors [71]. Hence, similarity is a crucial factor in metaphor processing [72], even though the fluency of ideas has also been found to be strongly related to the creation of novel metaphors [55]. While both conventional and novel metaphor generation are associated with attentional resources and inhibitory control, the process of creating novel metaphors involves a more intricate and diverse set of cognitive mechanisms, such as selective attention, divergent thinking and executive functions, which likely promote processes like cognitive flexibility and inhibitory control [73]. One common feature of these creative endeavors is found to be the semantic memory, which serves as the cognitive system responsible for storing factual information and knowledge, irrespective of the time or context in which it was acquired [50,74].

Therefore, the ability to access and connect disparate information from semantic memory contributes significantly to the generation of novel and innovative ideas, including naming unrelated words, proposing alternate uses and creating metaphors. Indeed, semantic distance is used in order to assess these creative tasks with high reliability and validity [47,55,75]. Nevertheless, the completion of these tasks relies on different semantic memory patterns: flexible and more interconnected semantic networks promote the high-creative production of metaphors [76]. Given the correlations obtained in this work, the metaphor generation, the alternate uses and the naming unrelated words tasks may require

high versatility in order to combine remote concepts while inhibiting obvious associations, resulting in a significant correlation between all tasks.

Conversely, there were no significant correlations between the naming unrelated words task and the alternate uses for a rubber tube task, which is in contrast with the correlation found by Olson and colleagues [47] for alternate uses for a brick task. However, the authors point out the role of the object used for the alternate uses task in the generation of responses. This fact may be related to the role of episodic memory, which is involved in divergent creative thinking and which enhances the production of ideas during the alternate uses task depending on the object considered and the personal experiences and profile of the subject [77].

5. Conclusions

This study has summarized evidence concerning the multifaceted assessment of linguistic creativity during students' last year of compulsory education in Spain. In particular, the results indicate moderate performance in divergent thinking tasks, while reporting limitations in generating novel metaphors. These findings point out the distinct yet interconnected processes underlying divergent thinking and metaphor generation. Understanding these processes is pivotal for designing and applying assessment tools to encompass various dimensions of creativity accurately within educational scenarios. Nevertheless, some potential limitations of this study have to be mentioned. Firstly, the sample of the study, although considerable, is not representative. Further studies will be carried out on a larger and more delocalized population. In addition, only the last course of compulsory secondary education has been investigated. Hence, expanding this research to all levels of secondary education would shed light on the progression of creativity competencies and the influence of the educational system on their promotion. Finally, the assessment tools used, although validated and widely used, may be refined and complemented by using additional instruments for different creativity domains, such as scientific [78] or artistic [79] domains, and also tests dealing with preferences and self-perceptions on creativity endeavors [80,81]. This combination may provide a more integrative and complete insight into the creativity profiles of students.

The results obtained for this Spanish population cannot be interpreted as positive and it will be necessary to corroborate them with the general measurements of the OECD PISA Tests when these are published. This organization has set an educational course based on competency learning, which implies the revaluation of creativity in educational systems, particularly in the Spanish one. The recent LOMLOE educational law clearly states this, but it is too early to be able to evaluate its effectiveness in the matter of channeling creativity [21]. At this point, three years after its implementation, the results related to creativity are not good, as demonstrated in this study. Thus, it is advisable to continue paying attention to the assessment of creativity but also to encourage technical training for teachers because they are thought to play a key role in the promotion of these competencies [82]. In particular, the creative behaviors of teachers may result in creative emulation by students [83]. Moreover, tailoring creative interventions to classrooms, by including multiple representations, digital tools, novel experiences and expecting unexpected responses, may nurture the creative abilities of students [84] because they no longer only have to study creators but rather become small (or big) ones. Moreover, it is imperative to adopt a transdisciplinary approach to promote creativity across all domains. The cultivation of creativity is not confined to a single subject area; instead, it needs integration throughout the educational spectrum. Consequently, training educators and educational professionals is essential, not only to raise awareness about the importance of creativity, but also to provide specific tools to design didactic interventions fostering transdisciplinary creativity [85,86].

In summary, the current study quantitatively examined the linguistic creativity of last-year compulsory secondary school students by means of tasks rooted in different creative processes. The results herein reported point out the importance of integrating creativity into educational policies and practices, calling for holistic approaches that recognize the

multifaceted nature of creativity since it is an essential competency for innovation and adaptability in this ever-changing world.

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Institutional Review Board Statement: Ethical review and approval were waived for this in accordance with the local legislation and institutional requirements.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The datasets generated for this study may be available under inquiry due to ethical considerations.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

The categories corresponding to the alternate uses task were those described by the authors of the standardized PIC-J test [57].

Table A1. Pearson's correlation coefficient of the creativity performance in the different tasks.

Category of Responses	Description of the Uses Proposed by Students
1	Blowing, smelling, slurping
2	Conduction
3	Playing, toys
4	Personal accessories
5	Storing
6	Attacking, weapons
7	Protecting, shelter, isolation
8	Holding
9	Scholarly uses
10	Sports
11	Construction
12	Sanitary and scientific uses
13	Looking into
14	General tools
15	Decoration
16	Home tools
17	Clothing
18	Grabbing, catching, dragging
19	Tying
10	Making noises
21	Travelling, transporting
22	Communication
23	Job tools (such as carpentry)
24	Molding
25	Floating
26	Indicating, lightening
27	Hiding
28	Recycling, change of state
29	Climbing, going up
30	Geometric assemblies
31	Connecting
32	Food
33	Body parts
34	Measuring
35	Magic or fantasy tools
36	Other uses not fitting in any of the above categories

From 1 to 7: 0 points of originality; From 8 to 18: 1 point of originality; From 19 to 24: 2 points of originality; From 25 to 36: 3 points of originality.

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The Letter of Notification

The letter is confirmed that the article "Scientific and Linguistic Creative Domains in Secondary Education. A Case Study in Spain" by the authors I. Pont-Niclòs, A. Martín-Ezpeleta, Y. Echegoyen-Sanz has been accepted for publication in European Journal of Contemporary Education. 2024. 13(1) (March issue). The journal is included in Scopus (Q2), WoS.

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Title: Scientific and linguistic creative domains in Secondary Education. A case study in Spain.

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Summary. Creativity has been included as one of the four C's of 21st-century skills essential for students to succeed both in school and in the workplace. Thus, many countries are including this topic in their educational policies. This is the case of Spain, where the last educational law (LOMLOE) states that creativity must be worked out in all subjects. In the process of assessing the real situation of the Spanish educational system in terms of creativity development and observing future changes regarding its implementation, this work presents a cross-sectional quantitative study. The performance of 223 students of the four grades of compulsory secondary education in

both the scientific and the linguistic domains of creativity was evaluated. Two instruments were used to measure daily and specific microdomains of scientific creativity and verbal-metaphorical microdomain of linguistic creativity. Results show a moderate to low development of creativity in secondary students in all studied domains of creativity. There were statistically significant differences according to gender, with women being the ones with greater creative skills. A progressive increase in creativity was observed up to the third year of compulsory secondary education, with a decrease in the last year. Finally, a positive correlation between scientific and linguistic creativity was established, in addition to an even higher correlation between both microdomains of scientific creativity. This study shows that there is still work to be done to promote creativity in the Spanish educational system, attending to the different subjects and creative domains. Some proposals are discussed, which highlight the importance of teacher training to achieve this goal.

Keywords: creativity assessment; Compulsory Secondary Education; creativity domains; scientific creativity; linguistic creativity.

Ключевые слова: оценка креативности; Обязательное среднее образование; творческие области; научное творчество; языковое творчество.

1. Introduction

Research on creativity has experienced an exponential development since the mid-20th century [Torrance, 1959; Guilford, 1967]. Currently creativity is considered a transversal and essential macro-competence in education [Kaufman, Sternberg, 2019]. Despite the difficulty of specifying a satisfactory definition, it has been agreed that creativity is an inherent capacity of the human being, which implies novelty or the production of something new and useful within a given context [Stein, 1953; Guildford, 1967]. Research in this field is focused in two different areas: personality characteristics associated with creativity and the different creative domains.

Regarding the personality characteristics of creative people, studies highlight that openness is one of the factors that has a more consistent and contrasted link with

creativity. Specifically, this factor is related to the curiosity to experiment, discover, and learn, in such a way that it encourages the ideas or products generated to be varied and unusual [Sánchez-Ruíz et al., 2017; Dollinger et al., 2004]. It is worth mentioning that the most recent works suggest that creativity has a componential nature, and it is influenced not only by personality characteristics, but also by affective, motivational and sociocultural aspects [Kaufman, Glăveanu, 2019].

On the other hand, the existence of different creative domains constitutes a hot and controversial research topic. In this context, a domain is understood as a specific area of knowledge, such as scientific, mathematic, linguistic, artistic, etc. that can be divided into different subdomains. Thus, the discussion centers on whether creative people are creative in everything they do, or only in those activities pertaining to a certain domain. Pioneering works in this field defended the existence of general creativity and, therefore, its transferability from one domain to another [Torrance, 1959]. However, subsequent studies point to the existence of different creative domains, with a person having different performances in each of them [Runco, Bahleda, 1986].

In this sense, the Amusement Park theoretical model [Baer, Kaufman, 2005], which includes both general and specific elements, is worth mentioning. It is based on a hierarchical structure in four levels: initial requirements, general subject domains, specific domains and microdomains. In the first place, initial requirements such as intelligence, motivation or the appropriate environment make it possible for creativity to appear in any domain. Second, the general thematic areas are associated with different areas of knowledge. The controversy is to establish how many and which domains exist. For example, Kaufman [2012] distinguishes five domains: everyday, scholarly, performance, scientific/mechanical, and artistic. Third, there are specific domains. Thus, within the general artistic domain, music, painting or dance are located. Finally, microdomains are associated with more specific creative tasks. For example, within writing, different microdomains can be distinguished depending on whether the generated product is a poem or a novel. In short, this hierarchical model is a powerful

theory, but limitations have also been noted, which stem mainly from the fact that distinction between levels and domains is not very precise.

Regarding the two domains analyzed in this study, more attention has been given to scientific creativity when compared to linguistic creativity. Research on scientific creativity is based on the fact that science and its generation of knowledge is based on creative processes. A recent meta-analysis [Julmi, Scherm, 2016] reinforces the idea of the existence of a specific scientific/mathematical domain, and it is known that mathematical education has an impact on the development of students' creative potential [Kontrová et al., 2021]. In any case, there is a strong consensus that scientific creativity is based on domain-specific knowledge (science knowledge) and other skills [Huang et al., 2017], and there are different instruments to measure scientific creativity in secondary education [Hu, Adey, 2002; Sak, Ayas, 2014; Hu et al., 2010]. On the other hand, the linguistic domain of creativity is closely related to the ability to generate metaphors and analogies [Veale, 2006]. These are used to create new ways of thinking about issues that may be familiar, but which involve exploring the boundaries separating conceptual categories to structure the world and, consequently, the use of words to communicate it [Ortony, 1993]. It should be noted that construction grammar, one of the main cognitive linguistic theories, has also recently been added to research on linguistic creativity [Hoffman, 2019].

Thus, it can be concluded that creativity is present in many different areas. It not only allows the production of works of art or musical pieces, but also business actions or cutting-edge scientific-technological advances. Furthermore, all these creative outputs in different domains share three characteristics: novelty, fitness for purpose, and utility. For all these reasons, the development of creativity is a key objective of education, since it has been explained that education directly influences six aspects affecting creativity: cognitive abilities, specific knowledge, the struggle to excel, openness to new ideas and experiences, collaboration, and motivation. This role of education in creativity might also be extrapolated, since the degree of creativity of the students influences not only their own person, but also the social and economic context [Tang, 2017]. From this more global perspective, creativity helps individuals to

identify problems and seek new solutions or improvements and, therefore, increases the probability of achieving individual and collective goals. In addition, it helps students to function in a constantly changing society. It seems clear that the future will generate the need for new professional profiles and especially an ability to adapt to a versatile world that depends largely on creativity [Kaplan, 2019].

This key role of creativity in the training of people has clearly been reflected in political-educational institutions. It is worth highlighting the relevance that the OECD has granted to creativity [OECD, 2019]. It has configured a competence framework for creativity and has incorporated the measurement of different domains of creativity in the 2022 edition of its PISA Tests. The OECD insists on the need to grant the space that creativity deserves in curricula. And this is what is happening in the case of the Spanish curriculum. The first mention to creativity can be found in the LGE law [BOE, 1970], but only for the Early Childhood Education stage. In the subsequent laws there is no mention to creativity but in the LOCE law [BOE, 2002] creativity is considered as a fundamental value for the development of society. It is established as a quality principle and as an objective to be achieved both in the Primary Education stage and in Baccalaureate. The LOE law [BOE, 2006] established creativity as an objective to be achieved in all educational levels. Finally, the LOMLOE law [BOE, 2020] highlights the transdisciplinary character of creativity, pointing out that "creativity will be worked on in all subjects" (p. 1222874). However, much work remains to be done to achieve this goal, starting with teacher training, the design of didactic materials to foster creativity and, finally, a better conceptualization of creativity and its importance in core aspects such as problem-solving.

With regard to the aforementioned 2022 PISA Tests, these must be interpreted as a turning point. It will allow us to have a global idea of the state of the development of creativity in Spain with respect to other countries (it is expected that the results are released on 2023) and it will also offer very sensitive data when discussing and triangulating complementary measurements. At this point, it should be noted that creativity assessment is still developing, since the construct of creativity, the debate over its distribution in domains, and even the assessment instruments require further

development. The case of Spain is not an exception because there are not many studies on student's creativity and rather located in specific populations, such as gifted students [Bermejo et al., 2010].

In this context, the present study aims to evaluate the creativity of 223 students from the four compulsory secondary education levels, taking into account the scientific and linguistic domains. Two more specific objectives are proposed: (1) to study the possible differences according to gender or level; and (2) establish the degree of correlation between scientific and linguistic creativity. The focus of this research makes it possible to determine the current situation of different creativity domains in Spanish classrooms. This is an essential prior step to design an educational plan focused on the development of creativity [Beghetto, 2019], which will be detailed in the conclusions section.

2. Method

This work presents an exploratory, cross-sectional, quantitative research design. It was developed in an educational center in the province of Valencia (Spain). The educational center is located in a medium size town (around 23.000 inhabitants) at 21 km of the capital of the province, with an average income close to 30.000 euros. Participants were 223 students homogeneously distributed in the four levels of compulsory secondary education. Table 1 shows the demographic characteristics of the sample.

Table 1. Demographic characteristics of the sample studied.

Level	Number of students	Age		Men	Women
		Mean	Standard deviation		
1st	57	12.38	0.49	28	29
2nd	55	13.21	0.46	22	33
3rd	57	14.44	0.50	29	28
4th	54	15.48	0.54	36	18

Data was collected in 50-minute sessions during the 2021-2022 academic year, the year before the implementation of the new LOMLOE law [BOE, 2020]. Prior to

the sessions, school management teams, legal guardians, and participants were informed about the treatment of the data and the scope of the research. Two previously validated instruments were used to assess the creativity of the students. They were presented as paper-based questionnaires, with the visual support of the projection of the corresponding statements on slides.

The first instrument, to assess scientific creativity, was developed by Hu et al. [2010] and is based on the establishment of scientific problems. It is inspired by the Torrance Test of creative thinking [Torrance, 1966], and assesses fluency, flexibility and originality. Fluency refers to the number of generated questions, flexibility to the number of knowledge areas in which these questions are framed, and originality arises from the statistical treatment of the data. This instrument includes two items. In the first one, participants are asked to generate scientific questions based on their life and daily observations (daily scientific creativity, DSC). In the second one, students are asked to formulate scientific questions related to an image of an astronaut on the moon (specific scientific creativity, SSC). Time was limited to 8 minutes per item, as in the original research. Hu et al. [2010] described the instrument as robust and reliable (with interrater reliabilities between .69 and .85).

The second instrument focuses on the linguistic domain of creativity, specifically the verbal-metaphorical microdomain, which is considered a central core of creativity [Kasirer & Mashal, 2018]. In summary, the ability to create metaphors is related to the linking of two apparently unrelated concepts, which reflects the ability to break the most conventional or obvious links, to establish new, more creative ones [Dietrich, 2004]. An instrument developed by Levorato and Cacciari [2002] and later adapted by Kasirer and Mashal [2018] has been used. It includes ten items, each of which corresponds to a feeling or emotion, such as joy, sadness, euphoria, or frustration. Five of these are presented to the participants with the aim of promoting figurative reformulation, such as "love is...", while the other five are presented as an analogy, such as "feeling frustration is like...". Time was limited to 8 minutes in total. Two judges coded the data independently, with an agreement rate of 89%. Any case of disagreement was discussed by both coders.

The procedure for data analysis of the answers to the first instrument was similar to that described by Hu et al. [2010]. Fluency was scored as the number of (valid) generated questions. To assess flexibility, a prior categorization of the questions was carried out [Pont-Niclòs et al, 2023], which resulted in 12 categories for DSC (the most common were "astronomy" and "functioning of the human body") and 7 categories for SSC (the most common were "characteristics of the moon" and "physical-technical aspects of the trip to the moon"). Flexibility was scored as the number of categories used per participant. For the originality assessment, the frequency of appearance of each question in the total sample was calculated. Those questions with a frequency of less than 5% received a score of 2; those with a frequency between 5% and 10% obtained 1 point; while those with a frequency of more than 10% did not add any points. Finally, the total scientific creativity score was obtained as the sum of the scores obtained for fluency, flexibility and originality. Regarding the second instrument, we proceeded as explained in Kasirer and Mashal [2018]. The questionnaires of each participant were evaluated independently, first discarding invalid answers (out of context or empty). Next, the answers were quantified according to three categories: literal answers (1 point), conventional metaphors (2 points) and new metaphors (3 points). The score for verbal-metaphorical creativity was obtained by adding the total scores obtained.

All collected data were treated anonymously and SPSS Statistics v26 program was used to carry out the pertinent statistical calculations. After determining the normality of the distributions using the Kolmogorov-Smirnov test, an inferential statistical analysis was carried out to assess the existence of significant differences between the variables. Thus, for the comparison between genders Mann-Whitney U test was used for non-normal distributions, and Student's t-test for independent samples for variables with normal distributions. For the comparison by level, Kruskal-Wallis test was used for non-normal variables and one-way ANOVA test for normal variables. The effect size was calculated using Hedges' g. To study the correlation between the different domains of creativity studied, the Pearson correlation coefficient was calculated. In all cases the level of statistical significance was set at 0.05.

3. Results and discussion

3.1. Scientific domain of creativity

In this study, two components of scientific creativity have been addressed: daily and specific. The first one was evaluated by means of an open question, while for the second one a closed question was used. These two components were analyzed according to the three variables described above (fluency, flexibility and originality); the sum of which gave rise to the total score. For DSC a high number of questions were related to wireless connections and ICT tools. Other recurring questions were related to the Universe, life on Earth or on other planets, or with means of transportation. On the other hand, for SSC the most common questions were linked to gravity, the presence of air on the moon or the possibility of life in the moon.

The total score for the two domains of scientific creativity studied (daily and specific) according to gender are shown in Table 2. Women generally show greater creative ability to formulate problems and scientific issues. This result is in line with other studies, according to which self-concept greatly conditions the creativity of students, who have assumed a certain social role marked by their gender [Nakano et al., 2021].

Table 2. Differences according to gender on the scientific creativity microdomains.

Microdomain	Gender	Mean	SD	z	p	Hedges's g
DSC	Female	21.79	7.10	3.39	.001**	.45
	Male	18.41	7.95			
SSC	Female	20.39	5.37	3.73	.000***	.50
	Male	17.30	6.83			

**There are significant differences with a significance level of 0.01
***There are significant differences with a significance level of 0.001

To check if the observed differences were statistically significant, Mann-Whitney U test was performed for DSC, and t-Student test was performed for SSC (see Table 2). As can be seen, there are statistically significant differences according to gender for

both types of scientific creativity ($p < 0.05$). The effect size was found to be moderate for DSC and strong for SSC, according to the classification provided by Cohen [1988] for behavioral sciences.

The results depending on the level of the students are shown in Table 3. It can be observed that, in both microdomains, these values are similar for the first two years, with a slight increase in the third year and a slight decrease in the last level of compulsory secondary education. The first increase can be justified by the development of the knowledge and skills in this stage since they have a positive impact on the performance of the creative processes. On the other hand, the decrease in the fourth year may be related to the disagreements typical of the adolescent age and a low motivation [Hu et al., 2010]. As can be seen, no statistically significant differences were found between courses for the two microdomains of scientific creativity studied ($p > 0.05$).

Table 3. Differences according to level on the scientific creativity microdomains.

Microdomain	Level	Mean	SD	z	p
DSC	1st year	19.56	7.47	1.75	.63
	2nd year	19.40	8.60		
	3rd year	21.00	7.02		
	4th year	20.20	7.83		
SSC	1st year	18.72	6.30	1.92	.13
	2nd year	17.62	6.46		
	3rd year	20.39	6.40		
	4th year	18.41	6.03		

3.2. Linguistic domain of creativity

The second instrument aimed to determine linguistic creativity, specifically the verbal-metaphorical microdomain. The qualitative analysis of the students' responses allows us to deduce that loneliness is for them synonymous with failure. On the other hand, numerous references to academic aspects can be identified in the generated metaphors. In the case of new metaphors (those awarded with three points), the most used resource is objectification or analogy with feelings generated in certain situations.

The total scores for verbal-metaphorical creativity according to gender are shown in Table 4. As happened for scientific creativity, women obtain better scores. Although these results are contrary to those presented by Kasirer and Mashal [2018], it should be considered that their sample was small (54 participants). In addition, there are other studies in the literature supporting the existence of significant differences between genders, derived from self-concept and pre-established social roles [Nakano et al., 2021] and similar results were obtained in a sample of Spanish first-year secondary students [Pont-Niclòs et al., 2023]. Results of Mann-Whitney U test show that these differences are statistically significant, with a moderate effect size.

Table 4. Differences according to gender on the verbal-metaphorical microdomain.

Microdomain	Gender	Mean	SD	z	p	Hedges's g
Verbal-methaphorical	Female	15.65	5.69	2.95	.003**	.33
	Male	13.65	6.42			

**There are significant differences with a significance level of .01

Regarding differences between levels, the total scores for verbal-metaphorical creativity are shown in Table 5. The trend is similar to that detected for scientific creativity, with the increase in this case between first and second years, similar values for second third years and a decrease in fourth year. This could be similarly explained by the development of knowledge and skills typical of the stage in the second year of compulsory secondary education and low motivation in fourth-year students. In this case, and unlike what happened for scientific creativity, Kruskal-Wallis test indicates that the observed differences are indeed statistically significant. To determine where the differences laid between groups Bonferroni test was applied. For $\alpha = 0.05$, the *post-hoc* analysis indicated statistically significant differences between fourth year and second year ($p = 0.033$) and fourth year and third year ($p = 0.046$), but not between the other groups ($p \geq 0.942$).

Table 5. Differences according to level on the verbal-metaphorical microdomain.

Domain	Level	Mean	Standard deviation	H	p
Verbal-methaphorical	1st year	14.07	6.45	10.13	.018**
	2nd year	15.47	6.25		
	3rd year	15.67	6.11		
	4th year	12.41	5.44		

**There are significant differences with a significance level of .01

3.3. Correlation between scientific and linguistic creativity

In the context of this research, it is essential to study a possible correlation between scientific and linguistic creativity. This is especially relevant attending to the intense debate on the existence of specific domains of creativity, or the consideration of creativity as a general construct. Huang and Wang [2019], for example, found positive correlations between general creativity and scientific creativity, but Bernal et al. [2017] pointed to domain-dependent creativity, having found no correlation between scientific and figurative creativity. Thus, the Pearson correlation coefficient was calculated for each of the microdomains studied. Table 6 shows the corresponding results.

Table 6. Pearson correlations between the different microdomains of creativity.

Microdomain	DSC		SSC		Verbal-metaphorical	
	r^2	p	r^2	p	r^2	p
DSC	1	-	.71	.000***	.43	.000***
SSC	.71	.000***	1	-	.42	.000***
Verbal-metaphorical	.43	.000***	.42	.000***	1	-

***Correlation is significant at the .001 level

As can be seen, there is a positive and significant correlation in all cases ($p < 0.05$), which indicates that students who are creative in one microdomain are also creative in the other two microdomains. Even though this result, a priori, could point out to the non-existence of creativity domains, a deeper analysis is needed. First, a very high correlation is obtained between the two aspects of scientific creativity studied ($r^2 > 0.7$), which indicates a presumable relationship between daily and specific scientific

creativity. However, the correlation between the two types of scientific creativity and verbal-metaphorical creativity, although positive, is clearly lower ($r^2 \approx 0.4$). This means that a particular student can show a good creative capacity that will be greater or lesser depending on the students' skill in that area of knowledge.

4. Conclusion

As explained, there is a certain difficulty in conceptualizing, measuring and, in short, understanding creativity in depth. There is, however, a consensus in the idea that creativity is fundamental for the development of people and their ability to function in different spheres of life. Thus, there is no doubt that creativity must occupy a nuclear space in educational debates and curricula. This will undoubtedly benefit from the impulse of the OECD and its PISA 2022 Tests.

This context legitimizes the interest in evaluating creativity in educational contexts, and, particularly, in Compulsory Secondary Education, which is the educational stage that PISA takes as a reference. Thus, the present investigation allows to measure and interpret very sensitive aspects related to the development of creativity of these students in the scientific and linguistic domains. There are some limitations, however, derived from the sample size and representativeness, as well as the deficiencies that, although validated and widely used by the scientific community, the assessment instruments used may have.

Firstly, it has been possible to verify that the Spanish students generally present a moderate to low level of creativity. Secondly, statistically significant differences were found according to gender, being female students those showing greater creative skills. On the other hand, there are also statistically significant differences between levels in daily scientific creativity and verbal-metaphorical creativity, obtaining similar trends for all the studied variables. Finally, positive correlations have been established between all the studied microdomains of creativity, with a greater correlation between both scientific creativity microdomains than between these and the verbal-

metaphorical microdomain. Thus, it can be deduced that students have a greater capacity to develop creatively in those domains in which they are more proficient.

It is essential to reflect on how and when to develop creativity in the educational system. Being creativity a very important macrocompetence, it is not correct to address it just in general terms or circumscribe it to specific domains such as art. The teacher training faculties have to intensify a reflection on the development of creativity, which is specified in three proposals. The first one is related to the training of preservice and in-service teachers. They must conceptualize creativity and its metacognitive processes, taking into account aspects such as students' cognitive styles [Prosekov et al., 2022)], as well as understand the teaching materials able to foster it. The second proposal involves a need to discriminate which didactic materials are able to develop creativity, using qualitative studies with a categorization taking into account the different creative domains. This is a preliminary step to verify that there are interesting materials that can be used, but also that it is urgent to design new didactic materials to foster a transdisciplinary development of creativity. Transdisciplinary because, as the last Spanish educational law (LOMLOE) specifies, it has to be carried out in all areas or disciplines. This could be done assimilating didactic approaches related to problem-solving or divergent thinking, for example. However, it is also interesting to design specific materials regarding a particular subject, knowledge field, or creative domain [Hu et al., 2013; Soboleva et al., 2022].

Finally, the third proposal implies a true transfer effort, with the most important conclusions of the theoretical and empirical studies on creativity having their projection in instructional and didactic changes. The legislative change of the LOMLOE is a propitious context because it not only highlights the importance of attending to creativity in all subjects, but also the autonomy of centers and teachers to decide how the syllabus should be implemented. The aforementioned transfer can also rely on manuals, courses or even workshops conducted by experts in creativity that can be a point of support for teachers. Then, they will become aware of the current state of creativity in the Spanish educational system, which the present study has contributed to outline.

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To whom it may concern

This document is to confirm that the article entitled "Creative self-perception of Spanish secondary teachers" authored by Isabel Pont-Niclòs, Yolanda Echegoyen-Sanz, and Antonio Martín-Ezpeleta has been preliminarily accepted for the publication at *Journal of Education, Culture and Society*. The article has received a positive review and has been accepted for editorial work for issue 2024_1 which will be published in June.

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dr Aleksander Kobylarek
JECS Editor-in-Chief

CUARTO ARTÍCULO

BELIEVE AND LIVE CREATIVITY AT SCHOOL. CREATIVE SELF-PERCEPTION OF SPANISH SECONDARY TEACHERS

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ABSTRACT

Aim. The aim of this research is to analyse the creative self-perception of Spanish secondary teachers in different creativity domains in a context in which creativity is increasingly being considered a key educational objective by organizations such as the OECD or educational laws, such as the recent Spanish one (LOMLOE, 2020).

Methods. Participants were 100 Spanish in-service teachers at the level of secondary education. They completed the K-DOCS questionnaire (Kaufman, 2012), in which the self-perception of creativity in five different domains (Self/Everyday, Scholarly, Performance, Scientific/Mechanic and Artistic) is assessed. The influence of variables such as gender, age, years of experience and area of teaching are analysed using inferential statistics.

Results. The analysis shows that Spanish secondary teachers have moderate-to-high perception of their own creativity. Although no statistically significant differences were found according to age or years of expertise, the scores in the Scientific/Mechanic domain were found to be significantly different according to gender. Separate creativity profiles were found for teachers with unrelated areas of expertise, with statistically significant differences in the Scientific/Mechanic and Artistic domains.

Conclusions. This study contributes to provide further insights into the role of teachers in the promotion/hindering of creativity in the classrooms. Results show a moderate creative self-perception with differences across domains, which logically conditions their conceptualization of creativity and the importance given to it in the classrooms. The importance of teacher training contributing to improve it is valued and key aspects are pointed out, such as the relevance of promoting a Centre Creative Plan with specific actions of a transdisciplinary nature in schools.

Key words: Creativity, 21st century skills, teachers, secondary education, self-perception

INTRODUCTION

Creativity leads to learning outcomes that meet many concerns of the current society (Glaveanu et al., 2019). Indeed, since the pioneer studies of Guilford (1950), promoting the creativity of students has long been viewed as an appropriate way to prepare students for an uncertain future. In fact, creativity is considered one of the 21st century skills (Thornhill-Miller et al., 2023), as the OECD has been highlighting for years and as is evident in the inclusion of a creativity assessment in its latest PISA tests (OECD, 2022). However, prior to discussing how education may shape creativity, it is important considering how creativity is conceptualized,

especially by teachers, since they are mostly responsible to opening spaces for creativity in the classroom.

The fact is that despite not existing a standard definition, creativity is regarded as a two-folded concept combining novelty and usefulness (Walia, 2019; Runco and Jaeger, 2012). In any case, it must be taken into account that what is considered original or appropriate may differ from one sociocultural context to another (Plucker et al., 2004). In addition, creativity researchers nowadays tend to understand creativity as a multi-domain construct (Hass et al., 2017), as the Amusement Park Theory stablished by Kaufman and Baer (2005) states. This theory considers that creativity includes both general and specific domains, and proposes a hierarchical structure for creative process, ranging from basic cognition, motivational and environmental requirements, to specific domains and microdomains related to particular tasks, such as writing poetry or solving a particular problem. Nevertheless, how many and which domains are included is still a topic of discussion among creativity researchers, since models fail at stablishing well-defined thresholds for each domain, whether any truly exist (Baer, 2010).

There are many studies focusing on a certain creativity domain. Thus, scientific creativity has been addressed by means of specific scientific productions or problem-solving patterns (de Vries and Lubart, 2019; Chen et al., 2016; Hu et al., 2010). Linguistic creativity has been measured as the generation of metaphors, since they are considered to be an explicit manifestation of creative thinking (Bergs, 2019; Bowdle and Gentner, 2005). Additional domains, such as music, art, or mathematics, are also analysed in several studies (Kladder and Lee, 2019; Mansour, 2018; Erbas and Bas, 2015). However, the comparison among different creativity domains has attracted a lot of interest in recent years. Also, their relationship with a general creativity construct has been addressed. Sometimes general creativity is wrongly exclusively associated to divergent thinking tests (Baer, 2015), and this is thought to lead to contradictory results (Kaufman et al., 2017).

Consequently, there has been an effort to embrace a much more integrative approach, assessing multiple domains of creativity, by means of a more accurate analysis design. In this context, researchers apply different approaches to form focal points to assess such a broad concept, although existing little consensus in the field as to how to suitably measure creativity (Long et al., 2022). For instance, Rhodes (1961) stablished the 4P model (person, process, product, and press) as a framework to analyse creativity from discrete perspectives. Then, Glaveanu (2013), transmuted the 4P model into the 5A classification (actor, action, artifact, audience, and

affordance). Regardless, the most widespread scheme to address creativity is known as the 4C: Big-C, as a genius-level creativity; Pro-C, as outstanding innovations which may yield to reach genius expressions; little-c, referred to individual creativity achievements such as meaningful insights or interpretations experienced at a learning process; and mini-c, related to everyday activities approached creatively (Kaufman and Glaveanu, 2021).

This scaffolding of creativity allows to identify relevant aspects to promote the development of creativity from one *c* to the upper one. While feedback is considered the vehicle to evolving from mini-c to Little-c, deliberate practice is essential for achieving creative outcomes not only at everyday life, but also at professional or academical level. Hence, opportunities to develop creativity should be provided within the classroom (Beghetto and Kaufman, 2014). In this regard there are multitude of techniques to assess the level of creativity of both teachers and students such as self-report questionnaires (Carson et al., 2005), divergent thinking tests (Kim, 2006) or personality tests (Costa and McCrae, 1992). In addition to these, there are more specific assessments centred in concrete creative domain, such as arts or science (Said-Metwaly et al., 2017; Lemons, 2011), which are designed in a wide variety of settings (Snyder et al., 2019; Karwowski et al., 2019; Acar and Runco, 2019; Cotter and Silvia, 2019). The results reported by those assessments generally point out to a multidimensional nature of creativity.

Therefore, teachers need to understand that and reinforce the relationships between learning and creativity processes on different domains (Thornhill-Miller et al., 2023). There are several factors influencing the development of creative potential at schools, from individual experiences, prior knowledge and personal preferences to environmental conditions (Glaveanu et al., 2019; Beghetto and Kaufman, 2014). However, among all these factors researchers are prone to consider that teachers have a remarkable influence in the promotion or hampering of students' creativity (Bereczki and Karpati, 2018). Different authors (Chan and Yuen, 2014; Yates and Twigg, 2017) even affirm that teachers must have previously developed their own creativity in order to develop students' creativity. That is why it is important to study different aspects related to teachers' creativity, and self-report assessments are widely used (Barbot et al., 2019; Cotter and Silvia 2019). This methodology is thought to capture aspects of creativity profile, motivation and expertise, related to day-to-day creativity endeavours and teaching practices (Kaufman, 2019).

There are various self-reported questionnaires to assess creativity in different domains, such as the Creative Behaviour Inventory (Hocevar, 1979), the Creative Achievement Questionnaire (CAQ)

(Carson et al., 2005), Biographical Inventory of Creative Behaviours (BICB) (Batey, 2007), or the Creative Actions Scale (CAS) (Elisondo, 2021). One of the most used is the Kaufman Domains of Creativity Scales (K-DOCS) (Kaufman, 2012), based on the APT mentioned above. It contains both domain-general and domain-specific conceptions of creativity, tapping into 5 large creativity areas (Everyday, Scholarly, Performance, Scientific/Mechanic, and Artistic). It has been extensively used to target different populations (Awofala and Fatade, 2015; Seng, et al., 2016; McKay et al., 2017), demonstrating that it is a reliable and valid instrument for assessing self-perceptions creativity in diverse contexts, such as education or the workplace. It has been translated into different languages, such as Chinese (Tu and Fan, 2015), Czechoslovakian (Plháková et al., 2015), Turkish (Kandemir and Kaufman, 2019), German (Brauer et al., 2022) and Spanish (Echegoyen-Sanz and Martín-Ezpeleta, 2021, Elisondo et al., 2022).

In Spain, the recent National Educational Law (LOMLOE, 2020) is in line with the OECD vision and states that "[...] artistic creation, audiovisual communication, digital competence, the promotion of creativity and the scientific spirit will be worked on in all areas […]" (p. 122873). In this context, it is appropriate to assess the creative self-perception of Spanish in-service teachers, since this population is not as studied as that of pre-service teachers (Echegoyen-Sanz and Martín-Ezpeleta, 2021; Pont-Niclòs et al., 2022; Martín-Ezpeleta et al., 2022; Martín-Ezpeleta et al., 2024).

OBJECTIVES

In the light of all the above stated, this study aims to evaluate the creative self-perception of Spanish secondary teachers. In addition, the influence of gender, age, years of expertise and area of teaching are likewise analysed. Therefore, the research questions nourishing this work are the following:

- What are the self-perceptions of creativity of Spanish secondary school teachers in different domains?
- Are there any significant differences depending on gender or age of teachers?
- Are those self-perceptions influenced by years of expertise and/or area of teaching?

METHODOLOGY

Participants consisted of Spanish secondary school teachers affiliated to eight different educational centres and practicing at the time of the study. Data reported was collected during the

academic year 2021-2022 and it corresponds to a total of 100 teachers specialized at different areas: Arts (N=3), Language and Literature (N=38), Math and Technology (N=18), Music (N=6), Natural Sciences (N=12), Physical Education (N=6) and Social Sciences (N=17). Age of teachers ranged from 25 up to 60 years old, with a mean value of 45.43 years, and a standard deviation of 9.43. In order to get insight into the influence of age on self-perception of creativity, different age groups ages were stablished: below 35, from 36 to 45, from 46 to 55 and above 56 years old. Similarly, different groups were defined considering their years of expertise in teaching: less than 5 years, between 5 and 10 years, between 11 and 20 years and more than 20 years. The global sample displays homogeneity of gender distribution: 48% of participants were female and 52% were male.

As mentioned before, the self-perception of creativity was assessed using the K-DOCS (Kaufman, 2012). The questionnaire includes 50 items related to 5 different creativity domains: Everyday, 11 items; Scholarly, 11 items; Performance, 10 items; Scientific/Mechanic, 9 items; and Artistic, 9 items. Participants were asked to compare themselves with pairs -with similarly age and life experiences- and then evaluate themselves in particular tasks, for instance "writing a poem" (Performance), "writing a computer program" (Scientific/Mechanic), "writing a letter to the editor" (Scholarly), "teaching someone how to do something" (Everyday) and "appreciating a beautiful painting" (Artistic). They indicated the degree to which they develop the tasks creatively, in comparison with their pairs, using a 5-point Likert scale as follows: much less creative (1), less creative (2), neither more nor less creative (3), more creative (4) or much more creative (5).

The validity of the Spanish translation, analysed by the Cronbach's Alpha method (Elisondo et al., 2022; Echegoyen-Sanz and Martin-Ezpeleta, 2021), was confirmed with alpha values above .76 for all domains. The data collection was carried out using an online version of the questionnaire, in order to facilitate the participation of the teachers, and all the demographic data was compiled simultaneously.

The statistical analysis was carried out using SPSS software (version 26). Specifically, the mean and standard deviation was calculated for each dimension of the questionnaire. The normality distribution of the data was checked using the Kolmogorov-Smirnov test. In order to elucidate the existence of significant differences between genders, either the t-Student or the Mann Whitney U tests were applied, for normal and non-normal distributions, respectively. Regarding the analysis of significant differences according to the age group, years of expertise and area of teaching, either One-way ANOVA (normal distributions) or the Kruskal-Wallis H test (non-normal distributions)

were used. Additionally, *post hoc* tests (either Bonferroni or Kruskal-Wallis pairwise comparisons) were carried out as needed to further explore those differences between groups of teachers. In all cases the significance level was .05. Effect sizes were calculated using Hedges's g or the formula for non-parametric data described by Field (2018). The magnitude of effect sizes was evaluated according to Cohen's classification for behavioural sciences (1988).

RESULTS AND DISCUSSION

The creative self-perceptions of Spanish secondary school teachers are shown in Table 1, corresponding to the scores of the different dimensions in the K-DOCS questionnaire (Kaufman, 2012). As it can be observed, secondary teachers have moderate-to-high self-perception of creativity across the different domains. Particularly, the highest scores have been found at the Self/Everyday domain followed by Artistic and Scholarly domains. However, Performance and Scientific/Mechanic domains have lower creativity self-perception profiles, being the latter the one with the lowest values among Spanish secondary teachers. These results are analogous to previously reported studies for Spanish primary pre-service teachers (Pont-Niclòs et al., 2022) and for a multi-background sample of Spanish people (Elisondo et al., 2022). Further, similar tendencies have been found for undergraduate students, either from Turkey (Kandemir and Kaufman, 2019) or US (Lee and Portillo, 2022), as well as for a general sample of German population (Brauer, 2022).

Table 1

Descriptive statistics corresponding to the different creativity domains

Creativity domain	Min.	Max.	Mean	Standard deviation
Self/Everyday$^{\phi}$	1.73	5.00	3.88	.70
Scholarly	1.92	5.00	3.66	.68
Performance	1.00	4.80	2.87	.92
Scientific/Mechanic	1.00	5.00	2.51	1.06
Artistic	1.78	4.89	3.14	.72

N = 100
$^{\phi}$: Non-normally distributed variable
Source. own. research

When analysing gender differences on the creative self-perception of secondary teachers, female and male teachers score slightly different at the assessed domains. As shown in Table 2, female teachers scored higher in Performance and Artistic domains. Conversely, males ranked higher at Self/Everyday, Scholarly and Scientific/Mechanic domains. Nevertheless, Student's t test (normally distributed variables) and Mann-Whitney U test (non-normally distributed variables) only show statistically significant differences according to gender for the Scientific/Mechanic domain, with a large size effect. Similar findings were reported at previous studies in which males rated themselves higher on Scientific-related domains, while women scored higher on Artistic domains (Elisondo et al., 2022; Pont-Niclòs, 2022; Kaufman, 2006; Kaufman et al., 2009). However, some studies have questioned these findings given the general tendency of females to underestimate their own abilities (Kaufman, 2019; Furnham, 2001).

Table 2

Differences on the creative self-perception of secondary teachers according to gender

Creativity domain	Gender	Mean	Standard deviation	z	p	g
Self/Everyday$^{\phi}$	Female	3.85	.67	-.570	.568	-
	Male	3.91	.73			
Scholarly	Female	3.63	.65	-0.324	0.747	-
	Male	3.68	.71			
Performance	Female	2.92	1.05	0.583	0.561	-
	Male	2.81	.79			
Scientific/Mechanic	Female	2.21	.87	-2.856	0.005**	0.57
	Male	2.79	1.15			
Artistic	Female	3.21	.74	0.848	0.398	-
	Male	3.09	.70			

ϕ: Non-normally distributed variable
***There are statistically significant differences at the .01 level*
Source: own research

When considering the influence of age or years of expertise in teaching (Tables 3 and 4) in the creative self-perception of secondary teachers, similar mean values are obtained for all groups studied. Further statistical analysis demonstrates that there are not significant differences between any group of teachers, which is in line with previous studies suggesting that experience and age of teachers have no effect on their perception of creative characteristics (Kettler et al., 2018). These results may point out the general statical character of teachers' professional development. It is considered that there is a lack of formation, support and training programs promoting the integration of creativity at the Education System. Therefore, more efforts are needed on teacher

formation, curriculum design and educational programs, directly addressed to not only enhance the creativity competences of teachers and students, but also to shed light into its relevance at the current educational and social paradigm (Hernández-Torrano and Ibrayeva, 2020; Vincent-Lancrin et al., 2019; Harris and De Bruin, 2018).

Table 3

Differences on the self-perception of creativity of secondary school teachers according to age

Creativity domain	Age (years)	Mean	Standard deviation	z	p	g
Self/Everyday$^{\phi}$	≤ 35	3.77	.77	.656	.883	-
	36-45	3.96	.59			
	46-55	3.88	.76			
	≥56	3.92	.66			
Scholarly	≤ 35	3.65	.62	.262	.853	-
	36-45	3.58	.63			
	46-55	3.72	.76			
	≥56	3.62	.65			
Performance	≤ 35	2.89	.95	.556	.645	-
	36-45	2.78	.89			
	46-55	2.98	.97			
	≥56	2.63	.80			
Scientific/Mechanic	≤ 35	2.17	.84	1.165	.327	-
	36-45	2.67	1.20			
	46-55	2.63	1.10			
	≥56	2.38	.92			
Artistic	≤ 35	3.15	.68	.251	.868	-
	36-45	3.04	.72			
	46-55	3.18	.75			
	≥56	3.22	.79			

ϕ: Non-normally distributed variable
Source: own research

Table 4

Differences on the self-perception of creativity of secondary school teachers according to years of experience

Creativity domain	Years of Experience	Mean	Standard deviation	z	p	g
Self/Everyday$^{\phi}$	< 5	3.83	.65	.720	.869	-
	5-10	3.94	.82			
	11-20	3.80	.76			
	>20	3.94	.65			
Scholarly	< 5	3.64	.65	.456	.714	-
	5-10	3.64	.64			
	11-20	3.55	0.66			
	>20	3.74	.73			
Performance	< 5	2.93	.89	.167	.918	-
	5-10	2.72	.89			
	11-20	2.91	.94			
	>20	2.84	.95			
Scientific/Mechanic	< 5	2.69	.92	1.154	.331	-
	5-10	2.03	.75			
	11-20	2.49	1.18			
	>20	2.59	1.11			
Artistic	< 5	3.00	.63	.764	.517	-
	5-10	3.29	.75			
	11-20	3.05	.74			
	>20	3.23	.75			

ϕ: Non-normally distributed variable
Source: own research

Further analysis of the creative self-perception according to the area of expertise of the teachers reveals that Arts and Physical Education secondary school teachers are prone to have higher self-perception of their creativity (Figure 1). In addition, while Natural Sciences and Math and Technology teachers display similar creative self-perception profiles, Social Sciences, Music and Language and Literature teachers display a different one. As it can be observed at Table 5, this is mainly related to their perception of creativity in the Scientific/Mechanic (higher for the former stated areas of expertise) and Performance dimensions (higher for the latter). In order to get insight into whether those tendencies were statistically significant, One-way ANOVA (normally distributed variables) and Kruskal-Wallis test (non-normally distributed variables) were carried out. The results are shown at Table 5, there are only two creativity domains for which a statistically significant difference is found: Scientific/Mechanic and Artistic.

Table 5

Differences on the self-perception of creativity of secondary teachers according to area of expertise

Creativity domain	Area of expertise	Mean	Standard deviation	z	p	g
Self/Everyday$^{\phi}$	Natural Sciences	3.62	.62	11.217	.082	-
	Math and Technology	4.03	.60			
	Social Sciences	4.09	.70			
	Language and Literature	3.71	.71			
	Music	3.82	.73			
	Arts	4.33	.63			
	Physical Education	4.31	.81			
Scholarly	Natural Sciences	3.49	.74	1.399	.224	-
	Math and Technology	3.54	.69			
	Social Sciences	3.86	.67			
	Language and Literature	3.62	.62			
	Music	3.35	.58			
	Arts	3.78	.63			
	Physical Education	4.21	.81			
Performance	Natural Sciences	2.32	.79	3.018	.06	-
	Math and Technology	2.54	.83			
	Social Sciences	2.6	1.02			
	Language and Literature	3.07	.86			
	Music	3.60	.61			
	Arts	2.80	.72			
	Physical Education	3.52	.83			
Scientific/Mechanic	Natural Sciences	2.83	.77	9.069	<.001***	-
	Math and Technology	3.64	.98			
	Social Sciences	2.32	1.02			
	Language and Literature	1.91	.72			
	Music	2.19	.67			
	Arts	2.81	.36			
	Physical Education	3.02	1.31			
Artistic	Natural Sciences	3.04	.62	4.1	.001***	-
	Math and Technology	3.05	.61			
	Social Sciences	3.29	.76			
	Language and Literature	2.98	.66			
	Music	3.22	.83			
	Arts	4.85	.06			
	Physical Education	3.37	.60			

ϕ: Non-normally distributed variable
****There are statistically significant differences at the .001 level*
Source: own research

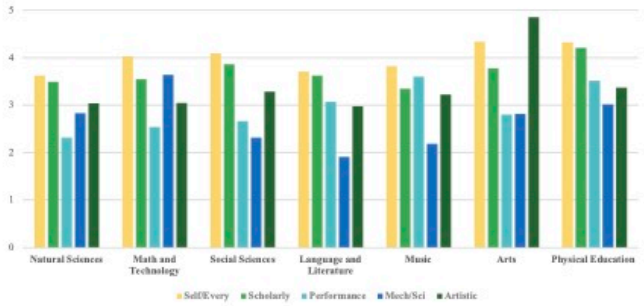

Figure 1. Mean values of the creative self-perception in the different domains for secondary teachers according to their area of expertise.

Aiming to shed light into the areas of expertise in which teachers have different self-perception of their Scientific/Mechanic and Artistic creativity domains, *post hoc* (Bonferroni) analyses were carried out. Regarding the Scientific/Mechanic domain, statistically significant differences, with large size effects, have been identified between Natural Sciences teachers and Language and Literature teachers ($p = .036$; $g = .52$), and between Math and Technology teachers and Social Sciences ($p < .001$; $g = .55$), Language and Literature ($p < .001$; $g = .71$) or Music teachers ($p = .013$; $g = .65$). It must be highlighted that in this domain, the creative self-perception of Language and Literature teachers is remarkably low ($M = 1.91$; $SD = .72$). These results may indicate a robust correlation between the background of teachers and their perceptions about creativity and innovation at different fields of education. This fact may be associated to the influence of the perception of self-efficacy in a topic or area of knowledge and the teaching experiences/collaborations (Perera et al., 2019; Ozder, 2011). Not surprisingly, for the Artistic domain, Arts teachers scored very high ($M = 4.87$, $SD = .06$) and statistically significant differences have been detected between them and the teachers from all other areas of expertise: Natural Sciences ($p = .001$; $g = 0.90$), Math and Technology ($p < .001$; $g = .90$), Social Sciences ($p = .006$; $g = .82$), Language and Literature ($p < .001$; $g = .89$), Music ($p = .016$; $g = .81$) and Physical Education ($p = .045$; $g = .87$), all with large size effects.

CONCLUSION

This study examines the creative self-perception of secondary school teachers at five different domains (Self/Everyday, Scholarly, Performance, Scientific/Mechanic and Artistic), revealing moderate-to-high scores for all of them. The throughout analysis of the data showed that gender differences were statistically significant, only for the Scientific/Mechanic domain. This fact may be interpreted by using traditional stereotypes, which commonly associate rather higher creative self-perceptions on the Scientific/Mechanic domain for males (Elisondo et al., 2022; Kaufman, 2006), although gender differences in creativity research are not fully comprehended (Caballero-Garcia and Sánchez-Ruíz, 2020). Regarding the influence of age and years of expertise of secondary school teachers on the creative self-perception, the data analysis showed no statistically significant differences. Hence, designing of training programs for secondary teachers are essential given the current educational paradigm (Cotter et al., 2022). Those programs should include practical tools to design teaching interventions with creativity at the core of teaching and learning processes, as well as theoretical information about the creativity construct and its assessment (Kaplan, 2019). Finally, the obtained results also highlight the dependency of the area of expertise and the creative self-perceptions of secondary teachers, which may be associated with self-efficacy and emotional/engagement processes (Elisondo et al., 2022; Perera et al., 2018).

Undoubtedly, further research is needed in this field, which would broaden the scope of this study. On the one hand, the factorial analysis of the K-DOCS questionnaire is currently being tested by different research groups to elucidate the most appropriate model (five or nine domains) to interpret data (Kapoor et al., 2021). On the other hand, a combination of self-reported questionnaires and objective creativity assessments may provide insights into the relationship of perceptions and actual creative abilities (Taylor and Kaufman, 2020; Kaufman, 2019). In addition, the sample, although sufficient, could be expanded to include different educational levels such as early childhood or primary education, and be more delocalized.

In any case, the present study contributes to provide further insights into the role of teachers in the promotion/hindering of creativity in the classrooms. Prior to encouraging students to be creative, teachers need to understand and recognize the importance of creativity and provide learning opportunities leading to the emulation of creative behaviours (Soh, 2017), such as technology-based creative activities (Bereczki and Kárpáti, 2021). There is the requirement of teachers intensifying a process of scientific conceptualization of creativity, which has been defined

as one of the key competences of the 21st century. Research studies as the one here presented are, therefore, necessary to know in-service teachers, before addressing a continuous training on creativity, which in the Spanish case is urgent with the new legislative changes of the LOMLOE, clearly aligned with the OECD.

Moreover, all this would be a starting point to develop programs and support guidelines for teachers to cope with the renovated paradigm established by the demands of the current society (Anderson et al., 2022). This needs a reflection starting from the assessment of the current situation to, in a second stage, implement measures such as a Centre Creative Plan in the school, grouping actions in favour of creativity in the classrooms. This plan entails not only to consider actions for each domain and disciplinary area, but especially those of a transdisciplinary nature. The latter could be exhibitions of inventions and art (the more heterogeneous the better) or conferences of creative people in different specialties (architects, advertisers, etc.). Perhaps this will ensure that creativity stops being a topic only for artists and becomes a topic for all citizens.

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Anexo II

Artículo Complementario

ARTÍCULO COMPLEMENTARIO

Scientific creativity in secondary students and its relationship with STEM-related attitudes, engagement and work intentions

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Abstract

The role of creativity in education is pivotal, since it is regarded as an essential skill enabling students to cope with future challenges, not only at their professional, but also at their daily life. Consequently, the assessment and improvement of creativity skills among secondary school students has been tackled both at international (OECD reports and the recent inclusion of creativity in the 2022 PISA tests) and national spheres (such as the LOMLOE law at Spain, in which this study is framed). In this context, this longitudinal quasi-experimental study explores the scientific creativity performance of Spanish secondary students (N = 780) and its relationship with their attitudes and engagement towards science, and work intentions in STEM-related careers. Results show a noteworthy deficiency in scientific creativity, in terms of problem-finding abilities, alongside with moderately accurate and positive perceptions about how science works and its individual and collective implications. In addition, limited engagement in science-related activities and a low rate of expectations in pursuing STEM-related careers have also been detected. Gender differences were found in scientific creativity, as well as perceptions and career expectations related to science. No differences were found in the scientific creativity across the levels of compulsory secondary school, but an improvement in perceptions about science was observed as the students progressed in the educational system. Nevertheless, a decrease in the rate of engagement and willingness to embracing a STEM-related pathway has also been detected in higher levels. Positive correlations between engagement and career expectations related to science were also found. The importance of nurturing scientific creativity is discussed in terms of enriching learning experiences and the design of interventions and specific policies. Finally, the impact of implementing creativity-focused educational strategies is highlighted in order to promote interest in pursuing STEM careers beyond the obligatory boundaries of education.

1 Introduction

One of the main issues dealing with students' engagement with STEM (science, technology, engineering and mathematics) subjects is the deeply rooted perception that those are complex and detached from reality. This is directly related to a lack of concentration and perseverance, which contributes to expand the barrier for diving into a STEM-related academic journey (Tinto, 2010). This challenge hinders the scientific literacy, specifically at secondary school levels. In this context,

conventional teaching methods that emphasize memorization, often divorced from real-life contexts, persist despite their drawbacks (Allchin, 2014). This approach fails to engage students with scientific concepts, leaving them uninterested and struggling with comprehension. Bridging these concepts to everyday life is crucial; dismissing this approach solidifies disinterest in STEM subjects, and particularly in science (Chambers et al., 2019).

According to the recently published results of the Program for International Student Assessment (PISA), there is a notorious general decrease of the performance at science, mathematics and reading, since the implementation of the program (OECD, 2023). Considering the case of Spanish data, mean performance in all three subjects was significantly lower in 2022, when compared to 2012 and 2015 editions. Indeed, the number of 15-year-old students scoring below the basic level of performance (Level 2) increased in all three subjects (over the 2012-2022 period). However, over 79% of Spanish students achieve, at least, this level. Consequently, those students are supposed to be able to recognize the correct explanation for familiar scientific phenomena and can use such knowledge to identify, in simple cases, whether a conclusion is valid based on the data provided. Nevertheless, they were not able to creatively and autonomously apply their knowledge of and about science to a wide variety of situations, including unfamiliar ones (OECD, 2023). Hence, students are not thought to be equipped with the necessary creativity skills and competencies to cope with the current society paradigm, in which uncertainty and change are the main characters. Within this landscape, there is predominant research focused on evaluating student learning outcomes and performance in light of the widely recognized 21st-century skills (Xia et al., 2022). Among these essential competencies, creativity stands out as a subject of considerable interest across diverse disciplines, since it embodies a pivotal human capacity, encompassing intra and inter-psychological processes that profoundly influence individuals personally and collectively (Sawyer, 2021; Beghetto, 2016). Moreover, creativity has been strongly related with problem-solving abilities, divergent thinking, metacognition processes and remote-associations construction (Jia et al., 2019), which are essential in STEM-related endeavors, as developed below.

1.1. Creativity and STEM subjects

Despite the existence of a vast number of creativity definitions at the literature, those commonly embody two pivotal traits: novelty and utility (Stein, 1953). Novelty is associated to uniqueness or originality, while utility is referred to meaningfulness or appropriateness (Runco and Jaeger, 2012). Moreover, it is widely accepted that the nature of creativity is multi-componential (Barbot et al., 2019). Hence, diverse theoretical and empirical frameworks, stemming from various psychological perspectives, delve into this phenomenon. Additionally, understanding the mechanisms underlying creative performance is critical. Models such as the "Four P model" (Rhodes, 1961) or the more recent "Four C model" (Kaufman and Beghetto, 2009) help to delineate different levels of creative expression. Those frameworks capture various manifestations of creativity during the learning process, emphasizing the intertwined nature of creativity and learning (Lemmetty et al., 2021). Particularly, by providing access to diverse perspectives, knowledge and experiences, STEM education plays a crucial role in developing creativity in conjunction with other essential skills, such as communication, teamwork, and adaptability (Harris and De Bruin, 2018), which in turn broad personal, professional, and collective objectives (Vincent-Lancrin et al., 2019).

The relationship between creativity and education is often addressed by assessing the influence of personality traits, cognitive factors, or educational programs on creative processes. These studies often rely on diverse instruments and settings to assess creativity (Hernández-Torrano and Ibrayeva, 2020; Sahin et al., 2023). The assessment methodologies primarily include three major approaches:

evaluating creativity through accomplishment, profiling individual characteristics related to creative potential, and evaluating creativity potential via predefined tasks (Thornhill-Miller et al., 2023). Techniques employed in these approaches range from expert evaluations to self-report questionnaires, divergent thinking tasks, such as the Torrance Tests of Creative Thinking (TTCT; Torrance, 1972), to personality tests (Costa and McCrae, 1992), among others. Several reviews have been published aiming to provide a comprehensive overview of creativity assessment approaches (Snyder et al., 2019; Karwowski et al., 2019; Acar and Runco, 2019; Cotter and Silvia, 2019). Furthermore, emphasis on accuracy, homogenization, and transparency in reporting creativity results is regarded as critical for advancing on creativity research, despite its complex and multidimensional nature (Barbot and Said-Metwaly, 2021).

Indeed, the existence of creativity domains has been extensively discussed since the early stages of this research field (Guildford, 1950). Nevertheless, in recent years a consensus has grown acknowledging the multi-componential nature of creativity, compiling both domain-specific and general features and also including social and cultural interconnections (Glaveanu 2020; Baer, 2012). From a theoretical point of view, the well-known Amusement Park Theory (APT) (Kaufman and Glaveanu, 2019) states that there are four hierarchical stages that allow creative processes to occur. These include from initial requirements that must be present, such as a supportive environment or a basic level of intelligence and interest; knowledge at general thematic areas, such as science or arts; to specific domains and microdomains, which correspond to concrete sub-themes and tasks (Baer and Kaufman, 2005).

In this regard, there are numerous studies in the literature focused on specific areas of creativity (Said-Metwaly et al., 2017), such as scientific creativity (de Vries and Lubart, 2019; Chen et al., 2016; Hu et al., 2010), linguistic creativity (Bergs, 2019; Bowdle and Gentner, 2005), and other knowledge areas like music, art or mathematics (Leikin and Sriraman, 2022; Kladder and Lee, 2019; Mansour, 2018; Erbas and Bas, 2015). Therefore, even though divergent thinking tests, are still the most commonly used (Kapoor et al., 2021), researchers are recently more prone to adopt a more comprehensive approach by evaluating multiple areas of creativity. This implies not only evaluating isolated creativity domains, but considering the relationships between them and exploring how they influence each other (Long et al., 2022), as well as taking into account further key aspects that forge one's individual creativity profile (Glavenau et al., 2020), such as life satisfaction, engagement, positive emotions and academic preferences and performance (Bekker et al., 2023; Caballero-García and Sanchez Ruiz, 2021; Conner and Silvia, 2015). In this context, the impact of teaching strategies that allow students to express their creativity have been proved to be remarkably relevant, not only at learning outcomes, but also at their attitudes towards science (Bi et al., 2020; Aguilera and Perales-Palacios, 2020). Regarding STEM-related subjects, some studies proved that project-based STEM learning enhances the creativity of students (Salmi et al., 2022; Hanif et al., 2019), while other studies point out to the influence of creativity in STEM-related career choices (Higde and Aktamis, 2022; Conradty and Bogner; 2019).

1.2. Scientific creativity

As mentioned above, despite not having a standard definition of creativity, its multi-dimensional character is well-acknowledged among researchers of the field, and it is considered to include specific-domains, general-domains and further aspects related to personal, social and cultural traits (Glaveanu et al., 2020; Baer, 2012). Among all the possible dimensions, relatively limited attention has been paid to scientific creativity in comparison to artistic or linguistic domains of creativity (Hernández-Torrano and Ibrayeva, 2020; Raj and Saxena, 2016), for example. Nevertheless,

scientific creativity differs from other dimensions, since specific knowledge and skills are needed to perform creatively in any given scientific creativity endeavor, such as experimental practices or problem finding and solving. Consequently, general/specific knowledge and skills, as well as divergent and convergent thinking, are considered to play a key role when approaching science education creatively (Yildiz and Yildiz, 2021; Zulkarnaen et al., 2018). In this regard, scientific creativity may be conceptualized as an interplay of knowledge, skills and divergent/convergent thinking, which provides a creative pathway to science (Mukhopadhyay and Sen, 2013; Heller 2007; Klahr, 2000). In addition, the students' ability to think creatively and to produce creative outcomes at STEM subjects is thought to be analogous to professional scientists' endeavors, regardless the evident differences between formal scientific work and scientific education (Kind and Kind, 2007). Those are the reasons why nurturing and cultivating scientific creativity of students is essential, not only to enhance their academic performance, but also to increase their self-efficacy/self-concept and in turn encouraging them to pursue a science-related academic journey (Xu, 2023; Tytler, 2014; Taskinen et al., 2013; Lent et al., 1986).

In this context, prior to developing interventions and curricular programs addressed to promote creativity in the scientific dimension it is essential to explore the scientific creativity of secondary students, their potential and limitations (Hu et al., 2023; Alves-Oliveira et al., 2022). Several instruments have been used for measuring scientific creativity (Ayas and Sak, 2014; Hu and Adey, 2002; Hu et al., 2010) based on different creativity aspects, such as curricular science knowledge and skills related to experimenting and managing data from observation, generation of scientific products and analysis of scientific processes, or formulation of questions of scientific nature. They converge in the idea that scientific discovery stems on different aspects of the scientific method, such as searching for possible hypothesis, performing experiments, etc. (Aschauer at al., 2022). These instruments have been used not only to assess secondary school students' creativity (Hu et al., 2010; Pont-Niclòs et al., 2023), but also to get insight into the impact of teaching experiences in STEM subjects at creativity performance (Demirhan and Sahin, 2019; Jia et al., 2017).

Considering the imminent publication of the 2022 PISA creativity results and the still recent law modification within the Spanish educational system, which praises creativity as a key transdisciplinary pillar of students' formation (LOMLOE, 2020), it is imperative to reckon on studies assessing the scientific creativity of secondary school adolescents. This will serve to gain a better understanding of the prospects and chances in the design of specific interventions and programs, targeting the development of scientific creativity and the encouragement of students to pursue a science-related pathway. Thus, the main aim of this study is to assess the scientific creativity of Spanish compulsory secondary school students, and its relationship with their attitudes towards science, in terms of perceptions, engagement and career expectations. Particularly, the research questions that nurture this investigation are the following:

- What is the performance in scientific creativity of Spanish secondary school students?
- Which is the predominant nature of their perceptions, engagement and career expectations with regard to science?
- Are there any differences depending on the student's level or gender?
- Is there any correlation between scientific creativity and attitudes towards STEM subjects (particularly Sciences) in Spanish secondary school students?

2 Materials and methods

2.1 Participants

A total of 780 Spanish students pertaining to four different high schools from the eastern region of Spain participated in the study. The sample was selected through non-probabilistic and convenience sampling, which is one of the most common sampling protocols used when the aim of the research is to obtain insights about a particular aspect within a group of individuals. Hence, the selection of the sample maximizes the understanding of the underlying studied phenomena (Onwuegbuzie and Collins, 2007).

The levels of the secondary school involved in this research correspond to the compulsory stage of the secondary education in Spain. Of the total sample, 210 participants were studying the first level of that stage (52.4% male, and 47.6% female); 207 students correspond to the second level (53.6% male and 46.4% female); 169 of them were studying the third level (49.7% male and 50.3% female), while 194 participants were adscripted to the last level of compulsory secondary education (51.0% male and 49% female). Regarding the ages of students of each level, those were between the typical ranges within the educational system in Spain, being 12 for the first (M = 12.3; SD = .6); 13 for the second (M = 13.4; SD = .5); 14 for the third (M =14.3; SD = .5); and 15 for the fourth level (M =15.3; SD = .6).

2.2 Design and procedures

This study corresponds to an exploratory and semi-empirical research (Cohen et al., 2002), carried out during the 2021-2022 academic year. Specifically, previously reported, and validated instruments were used to perform a quantitative analysis. The procedure began by explaining our research project to the headmasters of a selection of high schools situated in the Valencian Community. Those willing to participate received more detailed information about the research, protocols and data processing. That information was appropriately distributed to parents and legal tutors of students, which signed an informed agreement form to collaborate in the study. After that, one class session (c.a. 50 minutes) was used for students to complete paper-based questionnaires. During the session both the teacher in charge of the students' group and a researcher were present. The combination of informed consent with the anonymity and confidentiality of responses ensures the ethical principles and requirements established by the Ethics Committee of the University of Valencia.

2.3 Instruments and data collection

Both daily (DSCI) and specific (SSCI) scientific creativity were assessed by means of the questionnaire developed by Hu and colleagues (2010), which is based on problem-finding abilities and combines two types of instruction: opened and closed. This set-up is addressed to evaluate all potential creativity outcomes related to scientific problem-finding, whether those stem on every-day observations or specific knowledge about science-related matters. Hence, the questionnaire includes two subsequential items, one corresponding to the opened and other to the closed instruction. Directions were shown as slides during the session and the researcher was available for participants to ask any further inquiry. Students had a total of 16 minutes (8 minutes for each item) to complete the questionnaire. Firstly, students were asked to generate science-related questions, based on their life/daily experiences and their own curiosity, from as many perspectives as they could, and as unique as possible (opened instruction). Secondly, participants were asked to generate as many scientific questions as possible related to an image of an astronaut at the moon (closed instruction). The scoring process is based on the TTCT conceptualization of creativity (Torrance, 1972).

Consequently, the questions generated by students were assessed by means of a three-folded framework consisting on fluidity, flexibility and originality: fluidity corresponds to the number of questions generated by each student; flexibility is scored as the number of knowledge areas used in order to generate those questions, with 12 categories included for DSCI and 7 categories for SSCI (Pont-Niclòs et al., 2023; see Table S1 and Table S2 included at the supplementary material); and originality emerges from a statistical treatment of the data, since it is related to the frequency percentage of a particular generated question within the whole sample (2 originality points if the frequency percentage is lower than 2%, 1 point if the frequency is between 5% and 10%, and 0 points if above 10%). The total score for each scientific dimension is calculated as the sum of the fluidity, flexibility and originality scores.

The perceptions and engagement of students regarding science were assessed with a questionnaire adapted from a validated scientific literacy survey (Wu et al., 2019; Huang, 2012). On one hand, items corresponding to the "perceptions" dimension were based on epistemological and ontological concepts in conjunction with assumptions about the influence of both science and technology on society (Osborne et al., 2003). On the other hand, the "engagement" dimension was rooted on the conceptualization of enjoyment and intrinsic motivation on leisurely science learning (Ryan and Deci, 2009) and involvement on scientific activities as a source of pleasant life experiences (Nugent et al., 2015). Finally, the expectation to pursuing a science-related career was evaluated via items at the section ST113 (students' attitudes towards science and expectations of science-related careers) from the PISA 2015 tests (OECD, 2016). Those items are based on the instrumental motivation to learn science, in terms of usefulness for students to pursuing their future studies or careers (Wigfield and Eccles, 2000). Items 1 to 6 correspond to the "perceptions" dimension, whereas items 7 to 12 correspond to the "engagement" dimension, and items 13 to 16 assess the willingness to develop a scientific career (see Table S3 included at the supplementary material). A four-point Likert scale was used to score each of the items. The final score for each of the above-mentioned dimensions was calculated as the mean/median value of the items included in that dimension.

2.4 Data analysis

The statistical analysis of the data was carried out with the software IBM SPSS Statistics (version 28). Firstly, descriptive analysis of the sociodemographic and assessed variables was performed (frequencies, percentages, mean, standard deviation, median and IQR) to elucidate the general characteristics of the sample. Secondly, Kolmogorov-Smirnov test was applied to get insight into the normality of the sample distributions. Since the normality assumption was not corroborated for any of the studied variables ($p < .001$ for all variables), non-parametric tests were used. Particularly, Kruskal-Wallis test was applied to investigate differences among levels of compulsory secondary education, whereas Mann-Whitney U test was used to explore gender differences. The effect size was calculated using the formula described by Field (2018) for non-parametric samples. The magnitude of the effect size was evaluated according to Cohen's classification for behavioral sciences (1988), being small (up to .2), medium (from .2 to .5) and large (higher than .5). Finally, the correlation among variables was estimated by means of Spearman correlation coefficient. In all cases, the level of statistical significance was .05.

3 Results

3.1 Assessment of daily (DSCI) and specific (SSCI) scientific creativity

Scores corresponding to daily and specific dimensions of scientific creativity of Spanish secondary school students are shown at Table 1. Regarding fluidity (number of questions generated by student), the mean value is lower for the DSCI (M = 6.8, SD = 3.9, Me = 7.0) than for SSCI (M = 8.1, SD = 4.0, Me = 9.0), although the former corresponds to an opened instruction and the latter to a closed one. Considering the flexibility parameter (the quantity of knowledge areas included by each student in their questions), the value for daily (M = 3.8, SD = 1.7, Me = 4.0) and specific dimensions (M = 4.1, SD = 1.4, Me = 5.0) are analogous. Nevertheless, it is essential to note that the areas defined for each dimension differ from each other (Table S1 and Table S2 included at the supplementary material), since the spotlight of DSCI and SSCI encompasses distinct scopes of science.

Table 1. Descriptive statistics for the studied dimensions of scientific creativity

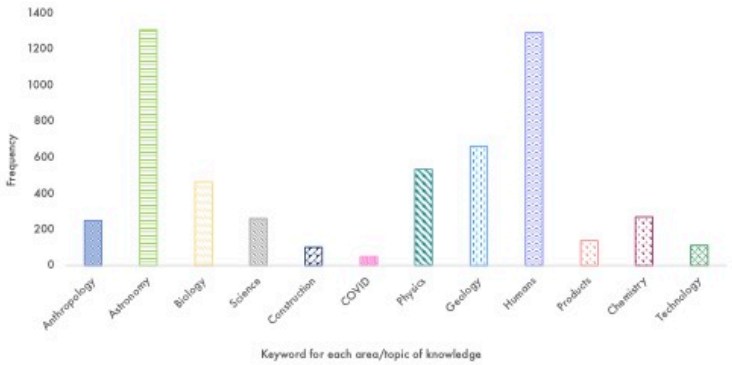
	Daily Scientific Creativity (DSCI)						Specific Scientific Creativity (DSCI)					
Parameter	**Min**	**Max**	**M**	**SD**	**Me**	**IQR**	**Min**	**Max**	**M**	**SD**	**Me**	**IQR**
Fluidity	0	27	6.8	3.9	7.0	5.0	0	28	8.1	4.0	9.0	5.0
Flexibility	0	9	3.8	1.7	4.0	2.0	0	7	4.1	1.4	5.0	1.0
Originality	0	8	2.5	1.5	2.0	3.0	0	6	1.7	1.0	1.0	1.0
Total	0	39	12.5	6.5	14.0	7.0	0	39	13.0	5.5	15.0	7.0

M: mean; SD: standard deviation; Me: median; IQR: interquartile range

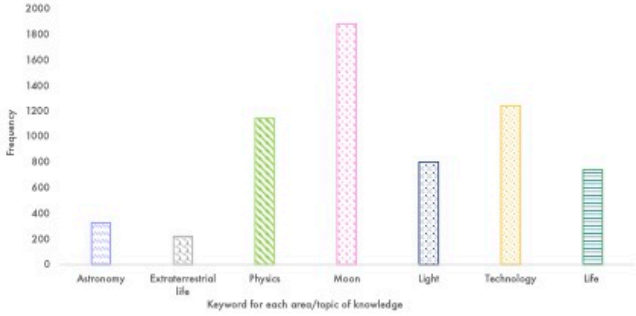
Particularly, Figures 1 and 2 show the knowledge areas mostly used by students, for DSCI and SSCI, respectively. As it can be observed, with the open instruction of DSCI test, students resort to the fields of astronomy or human body/health in order to formulate their scientific inquiries, while the areas related to the Moon's composition and meteorology, spatial technology/communications and physics (gravity, space motion) are mainly used in order to create questions related to the image of the astronaut at the moon (SSCI test). Concerning the originality scores, the scarcity of unusual or unique questions generated by students, for both DSCI (M = 2.5, SD = 1.5, Me = 2.0) and SSCI (M = 1.7, SD = 1.0, Me = 1.0) must be highlighted. Some examples of original questions produced by students at the DSCI dimensions are "why is the snow white if water is transparent?" or "why are we addicted to sugar?", while some examples of original SSCI questions are as follows: "is it possible to set a fire at the moon?" or "which sort of fuel did they use?".

277 Finally, the total value for creativity at each of the assessed dimensions, calculated as the addition of
278 the three parameters mentioned above, is remarkably lower than those reported by Hu et al. (2010)
279 for the equivalent grades assessed in this study.

280



281 **Figure 1. Number of questions formulated by students depending on the area of knowledge for**
282 **DSCI. Keywords for each area/topic of knowledge are described at Table S1 (supplementary**
283 **material).**



284

285 **Figure 2. Number of questions formulated by students depending on the area of knowledge for**
286 **SSCI. Keywords for each area/topic of knowledge are described at Table S2 (supplementary**
287 **material).**

288

3.2 Assessment of the perceptions, engagement and career expectations related to science

Table 2 shows the results of the descriptive analysis corresponding to each of the items used to assess perceptions, engagement and career expectations related to science of Spanish secondary students. Regarding perceptions, students display moderate awareness of the influence of science, individually and collectively, as well as sufficient knowledge about the epistemological and ontological principles of science (M = 3.0, SD = .4, Me = 3.0). It must be highlighted that from all items included in that category, the one corresponding to the versatility and dynamism of scientific knowledge (item 4) have the lower score (M = 2.5, SD = .9, Me = 3.0). With respect to the engagement category, values are slightly lower than the ones for perceptions (M = 2.3, SD = .6, Me = 2.2). This fact may indicate that students rarely enjoy or are prone to engage in science-related learning, activities, or events. Particularly, item 12 shows a notably low score (M = 1.5, SD = .8, Me = 1.0), indicating that students scarcely participate on divulgation events. The scores of item 11 (M = 1.9, SD = .9, Me = 2.0), which is associated with non-formal and autonomous processes of learning, are also low. Finally, the expectations to pursuing a science-related career are also low to moderate (M = 2.7, SD = .8, Me = 2.7), which may be correlated to the instrumental motivation of students. Therefore, values for all three considered categories are analogous, meaning that students are equally likely to understand the principles of science knowledge and perceive it as enjoyable as useful, when they expect to work in science-related occupations.

Table 2. Descriptive statistics for the perceptions, engagement and career expectations related to science.

Attitudes towards science	Item	Min	Max	M	SD	Me	IQR
Perceptions	1	1	4	3.2	.7	3.0	1.0
	2	1	4	2.8	.9	3.0	1.0
	3	1	4	3.5	.7	4.0	1.0
	4	1	4	2.5	.9	3.0	1.0
	5	1	4	3.2	0.7	3.0	1.0
	6	1	4	3.0	.8	3.0	2.0
	Total	-	-	3.0	.4	3.0	.5
Engagement	7	1	4	2.4	.9	2.0	1.0
	8	1	4	3.2	.9	3.0	1.0

	9	1	4	2.3	1.0	2.0	1.0
	10	1	4	2.2	.9	2.0	1.0
	11	1	4	1.9	.9	2.0	1.0
	12	1	4	1.5	.8	1.0	1.0
	Total	-	-	2.3	.6	2.2	.8
Career Expectations	13	1	4	2.8	1.0	3.0	2.0
	14	1	4	2.6	1.0	3.0	1.0
	15	1	4	2.8	.9	3.0	1.0
	16	1	4	2.6	1.0	3.0	1.0
	Total	-	-	2.7	.8	2.7	1.0

M: mean; SD: standard deviation; Me: median; IQR: interquartile range

309

310 **3.3 Differences according to gender**

311 Aiming to get insight into the role of gender on the scientific creativity performance and the
312 perceptions, engagement and career expectations related to science, inferential analysis was carried
313 out. Since none of the studied variables displayed a normal distribution, non-parametric Mann-
314 Whitney U test was applied (Table 3). As it can be observed, statistically significant differences have
315 been found for performance on both dimensions of scientific creativity. Further analysis of the data
316 reveals that girls outperform boys at DSCI (males: M = 11.7, SD = 6.4, Me= 11.0; females: M =
317 13.4, SD = 6.4, Me = 13.5) and SSCI (males: M = 12.0, SD = 5.6, Me = 12.0; females: M = 14.0, SD
318 = 5.2, Me = 14.0). Regarding the attitudes towards science, there are statistically significant
319 differences across genders for perceptions and career expectations, while there are not statistically
320 significant differences on engagement. Specifically, girls have more positive and accurate
321 perceptions of science (males: M = 2.9, SD = 0.5, Me = 3.0; females: M = 3.1, SD = .4, Me = 3.2)
322 and unexpectedly they are also more prone to pursing a science-related career (males: M = 2.5, SD =
323 0.8, Me = 2,7; females: M = 2.8, SD = .8, Me = 3.0). However, it must be taken into account that the
324 size effect for all those differences is small ($g \approx .2$).

Table 3. Descriptive statistics for the studied variables according to gender (N_{male} = 404; N_{female} = 376) and results of the Mann-Whitney U test.

	Gender	Mean	SD	Median	IQR	z	p	g
DSCI	M	11.7	6.4	11.0	7.0	4.0	<.001***	.1
	F	13.4	6.4	13.5	9.0			
SSCI	M	12.0	5.6	12.0	7.0	5.5	<.001***	.2
	F	14.0	5.2	14.0	6.3			
Perceptions	M	2.9	.5	3.0	.7	4.75	<.001***	.2
	F	3.1	.4	3.2	.6			
Engagement	M	2.2	.6	2.3	.8	0.83	.4	-
	F	2.3	.6	2.2	.8			
Career Expectations	M	2.5	.8	2.7	1.0	3.8	<.001***	.1
	F	2.8	.8	3.0	1.2			

M: male, F: eemale; SD: standard deviation, IQR: interquartile range
***: There are statistically significant differences at the .001 level*

3.4 Differences according to level

Tables 4 and 5 show the statistical descriptives for the scientific creativity performance and the perceptions, engagement and career expectations related to science of Spanish compulsory secondary school students. As it can be observed at Table 4, the values for both scientific creativity dimensions (DSCI and SSCI) are remarkably similar across levels.

Table 4. Descriptive statistics for the studied dimensions of scientific creativity according to level (N_1= 210; N_2= 207; N_3= 169; N_4= 194) and results of the Kruskal-Wallis test.

	Level	Mean	SD	Median	IQR	z	p
DSCI	1	11.5	6.5	12.0	9.8	6.3	.097
	2	13.1	6.6	12.0	7.0		
	3	12.4	5.6	12.0	7.0		
	4	13.2	6.9	13.0	8.0		
SSCI	1	12.8	5.4	13.0	7.0	1.2	.75
	2	13.4	5.8	13.0	7.0		
	3	13.3	4.8	14.0	6.0		
	4	12.7	5.8	13.0	7.0		

SD: standard deviation, IQR: interquartile range

However, some differences are apparent between students at the first level of Spanish compulsory secondary school and those at the upper levels, for the perceptions, engagement and career expectations variables (Table 5). Further analysis highlights an increase of the positive and accurate perception of science from the first level (M = 2.9, SD = .5, Me = 2.9) up to the fourth level (M = 3.2, SD = .4, Me = 3.2) and at the same time a decrease in the engagement category (1st level: M = 2.4, SD = .6, Me = 2.3; 4th level: M = 2.2, SD = .6, Me = 2.1) and the career expectations related to science positions (1st level: M = 2.9, SD = .7, Me = 3.0; 4th level: M = 2.5, SD = .9, Me = 2.7), from the first to the fourth level. Hence, the results of the non-parametric Kruskal-Wallis test revealed statistically significant differences among levels for the three categories (perceptions: $p < .001$; engagement: $p < .05$; career expectations: $p < .01$). To gain better understanding of those differences, a post hoc analysis (Bonferroni test) was performed. As expected by the inspection of the mean/median values, differences are mainly between the first level of compulsory secondary school and the higher levels. Specifically, for the perceptions category, there are differences between the first level and either the second ($p = .02$; $g = .2$), the third ($p < .001$; $g = .4$) and the fourth ($p < .001$; $g = .7$) level. In the case of the engagement category there are differences between the first level and either the third ($p = .02$; $g = .3$) and the fourth level ($p = .005$; $g = .3$). Finally, for the career expectations dimension, there are differences between the first level and either the third ($p = .03$; $g = .4$) and the fourth level ($p < .001$; $g = .5$).

Table 5. Descriptive statistics for the studied variables related to science attitudes according to level (N_1= 210; N_2= 207; N_3= 169; N_4= 194) and results of the Kruskal-Wallis test.

	Level	Mean	SD	Median	IQR	z	p
Perceptions	1	2.9	.5	2.9	.7	32.5	<.001***
	2	3.0	.4	3.0	.7		
	3	3.1	.4	3.2	.5		
	4	3.2	.4	3.2	.7		
Engagement	1	2.4	.6	2.3	.7	9.4	.024*
	2	2.3	.6	2.3	.7		
	3	2.2	.6	2.2	.8		
	4	2.2	.6	2.1	1.0		
Career Expectations	1	2.9	.7	3.0	1.0	12.4	.006**
	2	2.8	.8	2.8	1.0		
	3	2.6	.8	2.5	1.0		
	4	2.5	.9	2.7	1.0		

SD: standard deviation, IQR: interquartile range
**: There are statistically significant differences at the .05 level*
***: There are statistically significant differences at the .01 level*
****: There are statistically significant differences at the .001 level*

3.5 Correlation between scientific creativity and perceptions, engagement and career expectations of secondary school students related to science.

Lastly, to explore the potential correlation between the studied dimensions of scientific creativity (DSCI and SSCI) and the variables related to the students' attitudes towards science (perception, engagement and career expectation), Spearman's correlation coefficients (r_s) were calculated (Table 6). As it can be observed, there are strong positive correlations between both dimensions of scientific creativity (r_s = .52, $p < .001$), meaning that a student with high performance in the DSCI task, also

display an analogous ability at the SSCI task. Conversely, DSCI and SSCI have no significant correlation with neither the engagement nor the career expectations categories, although there is a positive correlation between the perception one with DSCI ($r_s = .12$, $p < .001$) and SSCI ($r_s = .12$, $p < .001$). Finally, there are strong correlations among the three categories exploring the attitudes towards science of students ($p < .001$ in all cases). Nevertheless, from those the highest value of the Spearman's coefficient corresponds to the duet engagement-career expectations variables ($r_s = .5$, $p < .001$).

Table 6. Spearman's correlation coefficients between the studied variables.

	DSCI	SSCI	Perceptions	Engagement	Career Expectations
DSCI	-	.52***	.12***	.05	.06
SSCI	.52***	-	.12**	.04	.08*
Perceptions	.12***	.12**	-	.33***	.34***
Engagement	.05	.04	.33***	-	.5***
Career Expectations	.06	.08*	.34***	.5***	-

*: *There are statistically significant differences at the .05 level*
**: *There are statistically significant differences at the .01 level*
***: *There are statistically significant differences at the .001 level*

4 Discussion

This study explores the scientific creativity of Spanish compulsory secondary school students. Particularly, two dimensions have been assessed: one related to every-day experiences (DSCI) and one to specific knowledge (SSCI). In addition, attitudes towards science have also been evaluated, aiming to shed light into any possible correlation between scientific creativity and perceptions, engagement and career expectations related to science of those students.

Found data have pointed out the low performance of students in scientific creativity (both DSCI and SSCI), particularly at the originality category. These results are in line with previously reported studies (Pont-Niclòs et al., 2023; Huang and Wang, 2019; Hu et al., 2010). Nevertheless, it must be considered that the assessment process has been mainly based on problem-finding abilities, and scientific creativity include several microdomains related to general/specific scientific knowledge and skills, as well as general/specific creativity competencies (Barbot et al., 2016; Hadzigeorgiou et al., 2012; Hu and Adey, 2002). Hence, scientific creativity may be assessed not only in function of problem-finding abilities, but also as performance on generating and testing hypotheses or problem-solving (Sternberg et al., 2020). Considering all the above stated, scientific creativity performance depends on multitude of factors related not only to the subjects' cognitive (de Vries and Lubart,

2019; Zhu et al., 2019) or metacognitive abilities (Jia et al., 2019), but also their science formation, personal experiences, interests and motivation (Yang et al., 2016; Collins and Amabile, 1999).

In this context, it is crucial to explore the influence of attitudes towards science on scientific creativity performance, since those may play a pivotal role on shaping the approach to cope with creativity and learning tasks (Hernández-Torrano and Ibrayeva, 2020; Conradty et al., 2020). The assessment conducted at this study, regarding perceptions, engagement and career expectations, has revealed students' moderate willingness and interest in science-related matters. Specifically, their conceptualization and thinking about the scope of science have been found to be relatively accurate and positive, which may be related to the teaching style that they have been confronted (Bereczki and Kárpáti, 2021; Southerland et al., 2001; Lumpe et al., 2000). Despite that, the obtained data have indicated a low rate of students that genuinely enjoy science, especially when referred to voluntarily participate at divulgation or non-formal learning activities (Christidou et al., 2022). Those factors, alongside with the learning processes that they have experienced at the science classroom (Steidtmann et al., 2023; Hampden-Thompson and Bennett, 2013), are directly related to the interest and motivation of students in pursuing a science-related professional pathway (Drymiotou et al., 2021). That may be the reason why the rate of students that are prone to follow a science-related professional life has been found to be relatively moderate as well (Jack and Lin, 2018).

Without underestimating the fact that these results may be influenced by sociodemographic factors, gender and level differences have been also assessed in this study. Specifically, gender differences have been found at both dimensions of scientific creativity (DSCI and SSCI), which is in consonance with similar studies (Pont-Niclos et al., 2023; Hu et al., 2010). These results sum up to the evidence of the role of gender in creative performance, even though the nature of that role is not fully understood, since it depends on additional personal and sociocultural factors (Nakano et al., 2021). Regarding attitudes towards science, no gender differences have been detected at the engagement category, although girls have slightly more accurate and positive perceptions about science, and they are barely more prone to pursuing science-related careers. Nevertheless, it must be taken into account that effect sizes are small, and scores hardly exceed 2 points (in a 4-point Likert scale), meaning that girls' expectations to embrace a science professional pathway are still moderate. These results are heavily influenced by what students perceived as a science-related career (medical doctor, software engineer, artist, architect or journalist) and the worthiness of school science at the daily and professional spheres. Consequently, data may highlight the narrow view of students about the usefulness of procedural or epistemic scientific knowledge at the real/professional world (OECD, 2016). In addition, it has to be considered that female traditionally have been associated to caring and non-time-consuming careers, while males are more prone to outcome-oriented occupations (Kang et al., 2018). Regarding students' level differences, researchers suggest that creativity can be, and must be, nurtured by appropriated training within the classroom to prepare students to cope with future demands of society (Alves-Oliveira et al., 2022; Beghetto, 2019). In this regard, statistically significant differences were expected among the levels of secondary school education. Unfortunately, no differences between levels have been identified on any of the dimensions of scientific creativity. That continuity in the creative performance throughout compulsory secondary education underpins the need to promote specific actions that carry policies and international efforts effectively into classroom routines, which translates to the intentional curriculum design and the formation of pre-service and in-service teachers in creativity conceptualization and development (Echegoyen-Sanz et al., 2024; Echegoyen-Sanz and Martín-Ezpeleta, 2021; Bereczki and Karpati, 2018). In addition, engagement and willingness to pursuing a science-related pathway of students show a decrease from the first level of compulsory secondary school to the higher level. This fact may be related to the disparity in approaching science learning from the beginner levels, generally stem on curiosity and

experimenting; to the advanced levels, typically more theoretical and disconnected from daily experiences (Yang et al., 2016), as also happens for other STEM-related subjects.

The interplay of scientific creativity and attitudes towards science has also crucial implications for any effort to promote creativity, scientific learning, and aspirations to continue studying sciences beyond the limits of compulsory secondary education (Conradty, et al., 2020). In this paper, the correlation between scientific creativity and an accurate and appreciative perception of science has been found to be slightly positive. However, scientific creativity performance was not correlated to engagement or career expectations of a science-based professional position. These findings may be related to the fact that scientific creativity requires of specific knowledge about the nature of science, its processes, and influences on society (Huang and Wang, 2019; Ozdemir and Dikici, 2017), although it may not be related to a particular scientific professional orientation, but the learning experiences that students have been confronted to (Chi and Wang, 2023). However, the three dimensions analyzed with respect to the attitudes towards science (perceptions, engagement and career expectations) show positive correlations, being the one between engagement and career expectations the strongest, indicating that an individual's choice of a future occupation is hugely influenced by personal preferences, interests and motivations, in spite that the whole decision process include intricated further factors (Vinni-Laakso et al., 2022; OECD, 2016, Taskinen et al., 2013).

5 Conclusion

This study explores the scientific creativity of Spanish secondary school students and its correlation with perceptions, engagement, and career expectations related to science. Findings shed light on several significant aspects dealing with scientific creativity performance and attitudes towards science. Firstly, the assessment of scientific creativity, encompassing both daily and specific dimensions, revealed a considerable shortfall among students (Pont-Niclòs et al., 2023; Hu at al., 2010). While the study primarily focused on problem-finding abilities, the multi-faceted nature of scientific creativity is emphasized, suggesting that a more comprehensive evaluation including various creativity competencies could offer a deeper understanding (Elisondo, 2021; Barbot et al., 2016; Kaufman, 2012). Secondly, students exhibited moderately positive and accurate perceptions about science, yet demonstrated limited interest and engagement in science-related activities outside, and even within, the classroom. Moreover, their willingness to pursue science-related careers remained relatively low, suggesting a need for more effective strategies to incite interest and motivation in science learning, as well as in other STEM subjects, beyond compulsory stages of education (Conradty et al., 2020). Regarding gender differences, those were appreciable in scientific creativity, aligning with some prior research (Nakano et al., 2021), while differences across levels of secondary education were not apparent. These findings highlight the necessity for targeted interventions that integrate policies promoting creativity and science education into classroom practices, ensuring continuity and enhancement throughout secondary education (OECD, 2023; Cotter et al., 2022; Yang 2016). In addition, the correlation between scientific creativity and attitudes towards science pointed out a strong relationship between engagement and career expectations in science-related fields (Ainley and Ainley, 2011), suggesting that fostering scientific creativity and enhancing the learning experiences, while learning specific scientific knowledge, may result in higher enrolment rates in science-related matters (Drymiotou et al., 2021; Struyf et al., 2019).

Despite its insights, this study has limitations that have to be taken into account. The assessment was primarily focused on problem-finding abilities, overlooking other dimensions of scientific creativity. Additionally, the cross-sectional design limits the depth of understanding longitudinal effects between creativity and attitudes towards science. Moreover, the study sample was confined to a

specific geographical area, which might restrict the generalizability of the findings. Further research may broaden the scope of this study, such as expanding the sample to other Spanish regions or including additional assessment tools addressed to evaluate diverse general and specific creativity domains, in conjunction with other tests dealing with self-perceptions in creativity endeavors or life satisfaction (Ivcevic, 2022; Caballero-García and Sanchez-Ruiz, 2021). This multi-approach may help to construct a more accurate and complete creativity profile of students, as a starting point to design effective teaching approaches, especially at STEM subjects (Tran et al., 2021).

It seems clear that integrating creativity into teaching methodologies could revitalize the engagement and interest in scientific matters, offering students a more solid connection between conceptual learning and real-world applications. For instance, teachers may provide examples of creative behaviors that students would be able to emulate (Jonas and Chambers, 2017). In addition, the use of Artificial Intelligence offers a novel framework to nurture creativity among students by its proper usage (Miao and Holmes, 2023). Indeed, fostering creativity equips students with essential skills, such as problem-finding/solving, divergent thinking, and metacognition, which are essential for coping with future challenges, particularly in STEM-related fields where adaptability and innovation are imperative (Perignat and Katz-Buonincontro, 2019).

In conclusion, providing engaging and holistic learning experiences could not only nurture scientific creativity, but also enrich the interest and motivation in pursuing science-related careers. Effective integration of creativity-focused educational strategies is needed for the training of a generation ready to embrace future challenges at a rapidly evolving world. However, further studies are needed to get more integrative insights, thereby bridging the gap between creativity, science education and career aspirations. This is a global and historical problem, but the present and future of STEM careers have creativity, a key competence of the 21st century, as their best ally.

6 Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

7 Author Contributions

IPN, AME and YES: conceptualization. AME and YES: methodology, project administration, supervision, resources and funding. IPN: investigation, data curation and formal analysis, writing - original draft. AME and YES: writing - review and editing. All authors contributed to the article and approved the submitted version.

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12 Data Availability Statement

The datasets generated for this study may be available under inquiry due ethical considerations.

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