Universidad de Granada

Programa de Doctorado en Ciencias Sociales

Gamificación como herramienta de educomunicación estratégica en la lucha contra el cambio climático:

Los juegos online en adolescentes

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PRESENTACIÓN

NORMATIVA

La presente tesis doctoral ha sido elaborada de acuerdo con la modalidad "compendio de publicaciones". Se ha preparado, pues, una memoria de trabajos previamente publicados en revistas científicas internacionales indexadas en las bases de datos del Journal Citation Report de Thomson Reuters y/o del SCImago Journal & Country Rank de Scopus.

La memoria ha sido redactada de acuerdo con lo establecido en las "Normas reguladoras de las enseñanzas oficiales de Doctorado y del título de Doctor por la Universidad de Granada", recogidas en el documento NCG61/1, que fue aprobado en la sesión extraordinaria del Consejo de Gobierno de 2 de mayo de 2012.

Estas normas establecen:
"[La tesis doctoral] debe contar, al menos, con los siguientes contenidos: título, resumen, introducción, objetivos, metodología, resultados, conclusiones y bibliografía. Una tesis doctoral puede también consistir en el reagrupamiento en una memoria de trabajos de investigación publicados por el doctorando en medios científicos relevantes en su ámbito de conocimiento.

Los artículos que configuren la tesis doctoral deberán estar publicados o aceptados con fecha posterior a la obtención del título de grado y del máster universitario, no podrán haber sido utilizados en ninguna tesis anterior y se deberá hacer mención a la Universidad de Granada a través de la afiliación del doctorando.

Si la publicación ha sido realizada por varios autores, además del doctorando, se debe adjuntar la declaración de los restantes autores de no haber presentado dicha publicación en otra tesis doctoral o la renuncia a hacerlo. Los coautores señalarán el trabajo del doctorando en los mencionados trabajos.

En esta modalidad, la tesis debe tener además de los apartados mencionados en el punto anterior, los artículos que la componen, bien integrados como capítulos de la tesis o bien como un Anexo.

El Comité de Dirección de la Escuela de Doctorado correspondiente podrá establecer el número mínimo de artículos necesarios para presentar una tesis en esta modalidad y las condiciones adicionales sobre la calidad de los trabajos".

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La tesis debe contar, al menos, con los siguientes contenidos: título, compromiso de respeto derechos de autor, resumen, introducción, objetivos, metodología, resultados, conclusiones y bibliografía.

En la tesis doctoral deberá figurar en las páginas iniciales una hoja donde tanto el doctorando como sus directores garanticen que se han respetados los derechos de otros autores a ser citados, cuando se han utilizado sus resultados o publicaciones".

Fuente:
http://escuelaposgrado.ugr.es/pages/doctorado/tramites_administrativos_alumnos_doctorado/tesis_doctoral [consultado: 10 de marzo de 2017].

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"La recomendación del Consejo Asesor de Doctorado es que para utilizar este tipo de formato se utilice un mínimo de tres artículos y que se incluya un informe con el factor de impacto de las publicaciones presentadas. En aquellas áreas en las que no sea aplicable este criterio se sustituirá por las bases relacionadas por la Comisión Nacional Evaluadora de la Actividad Investigadora (CNEAI) para estos campos científicos.

Las Comisiones Académicas de los Programas de Doctorado podrían requerir condiciones adicionales a las reflejadas en esta página web, debería ponerse en contacto con el programa para conocer si existen estas condiciones.

El doctorando debe respetar los derechos de propiedad intelectual relativos a la difusión de los artículos utilizados en la tesis doctoral".

Fuente:
http://escuelaposgrado.ugr.es/pages/doctorado/tramites_administrativos_alumnos_doctorado/tesis_doctoral [consultado: 10 de marzo de 2017].

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• Idioma de presentación de la tesis: parte de la tesis doctoral, al menos un resumen extenso y las conclusiones, debe redactarse y presentarse en una de las lenguas habituales para la comunicación científica en el campo de conocimiento en el que se enmarca el trabajo de investigación, distinta a cualquiera de las lenguas oficiales en España. Esta norma no será de aplicación cuando las estancias, informes y expertos/as procedan de un país de habla hispana.

• Informes de expertos/as: la tesis debe ser informada por un mínimo de dos expertas/os doctoras/es pertenecientes a alguna institución de educación superior o instituto de investigación no española (Informe de Experto (word-odt)). El informe se redactará en español o en inglés. La solicitud de estos informes se realizará una vez que el/la director/a o directores/as hayan autorizado la presentación de la tesis. Las/los expertas/os deberán cumplir los mismos requisitos que se exigen a los/las miembros del tribunal (se adjuntará informe de idoneidad).

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Las posteriores actuaciones con respecto a la mención de doctorado internacional, incluida la Solicitud de la misma forman parte del procedimiento de Depósito de Tesis Doctoral que podrá consultar en esta web.

Fuente:
http://escuelaposgrado.ugr.es/pages/internacional/mencioninternacional/mencion
[consultado: 10 de marzo de 2017].

ESTANCIAS

Para cumplir los requisitos de la normativa para la mención internacional, Dª Tania Ouariachi Peralta ha realizado una estancia de investigación de una duración de cinco meses en Center for Climate Change Communication de George Mason University (Virginia, Estados Unidos), financiada por la beca Ruth Lee Kennedy del Programa Fulbright, y por la beca de movilidad internacional de estudiantes de programas de doctorado Universidad de Granada y CEI BioTic Granada (convocatoria 2015/2016). El centro de investigación (junto a Yale, el único especializado en comunicación del cambio climático) es de reconocido prestigio mundialmente y alberga a uno de los principales investigadores en esta área de investigación, tales como su director, Dr. Edward Maibach.

La doctoranda también ha realizado una estancia académica de tres meses en Radboud University (Nijmegen, Países Bajos), financiada por el programa de ayudas de movilidad internacional Fundación CEIMAR destinadas a estudiantes de Grado Doctorado, en el marco del Programa Europeo Erasmus+ (convocatoria 2016/2017). El Behavioural Science Institute (BSI) de esta Universidad alberga un prestigioso programa de investigación en Communication Science, financiado por Netherlands Organisation for Scientific Research (NWO) y European Research Council (ERC), y está caracterizado por ser multidisciplinar y el único en el mundo que se especializa en "positive communication research". Líneas de investigación incluyen *persuassive communication*, *videogames for health* o *young consumers*.

Ambas instituciones se encuentran posicionadas en el ranking de Shangai.

PUBLICACIONES

A la vista de la citada normativa, hemos preparado una memoria con los siguientes contenidos: título, autorización de los directores de la tesis doctoral, compromiso de respeto de los derechos de autor, agradecimientos, resumen, introducción, objetivos y metodología, resultados, conclusiones y bibliografía. Dentro del bloque de resultados se incluyen los textos íntegros de cinco artículos originales publicados en revistas de impacto y un capítulo de libro en una editorial internacional de prestigio, que abordan desde distintas perspectivas los materiales que son objeto de estudio en esta investigación. En los siguientes párrafos se puede encontrar información a fecha de hoy sobre el factor de impacto de las cinco publicaciones presentadas:

1) **Ouariachi, T., Gutiérrez-Pérez, J., y Olvera-Lobo, M.D. (2017) "Criterios de evaluación de juegos online sobre cambio climático: aplicación del método Delphi para su identificación".** ***Revista Mexicana Investigación Educativa, 22*** **(73) (en prensa).**

La *Revista Mexicana Investigación Educativa* (ISSN: 1405-6666) es publicada por el Consejo Mexicano de Investigación Educativa (México).

H Index: 3

Factor de impacto: 0.348 en el año 2015 dentro del Scimago Journal & Country Rank.

Posición en su categoría:

470 (Q2) de 1066 en la categoría Education dentro del Scimago Journal & Country Rank en el año 2015.

Está indexada en las siguientes bases de datos:
- Scopus
- Indice de Revistas de Educación Superior e Investigación Educativa
- Latindex - Catálogo (Sistema Regional de Información en Línea para Revistas Científicas de América Latina, el Caribe, España y Portugal)
- Scientific Electronic Library Online
- Directory of Open Access Journals
- Thomson Reuters-Web of Science-Social Sciences Citation Index
- Índice de Revistas Mexicanas de Investigación - CONACYT
- Citas Latinoamericanas en Ciencias Sociales y Humanidades
- Índice Bibliográfico Publindex - A1 - Homologación
- Thomson Reuters-Journal Citation Report-Social Sciences Citation Index
- DIALNET-Clasificación Integrada de Revistas Científicas-Grupo C
- Qualis/Capes - A2 Homologación
- Qualis/CAPES - B2 Homologación

2) **Ouariachi, T., Olvera-Lobo, M.D. & Gutiérrez-Pérez, J., (2017). "Analysis of individual online climate change games targeting youth: proposing a checklist and exploring opportunities".** ***Revista Electrónica de Investigación Educativa*** **(REDIE), 19 (2) (in press)**

La *Revista Electrónica de Investigación Educativa* (REDIE) (ISSN 1607-4041) es una publicación cuatrimestral del Instituto de Investigación y Desarrollo Educativo de la Universidad Autónoma de Baja California

H Index: 3
Factor de impacto: 0.105 en el año 2015 dentro del Scimago Journal & Country Rank.

Posición en su categoría:

(Q4) 949 de 1066 en la categoría Education dentro del Scimago Journal & Country Rank en el año 2015.

Indexada en:

- SCOPUS
- IRESIE
- ICAAP
- CLASE
- LANIC
- DIALNET
- EBSCO
- DOAJ
- REDALyC
- LATINDEX
- OEI
- Sistema de Clasificación de Revistas Mexicanas de Ciencia y Tecnología (CRMCyT) del CONACYT
- PUBLINDEX
- SCIELO
- HAPI
- REDIB
- WEBQUALIS
- Scielo Citation Index (Web of Science)

3) **Ouariachi, T., Olvera-Lobo, M.D y Gutiérrez-Pérez, J. (2017). "Evaluación de juegos online para la enseñanza y aprendizaje del cambio climático". *Enseñanza de las Ciencias: revista de investigación y experiencias didácticas*, *22* (73), 193-214. DOI: 10.5565/rev/ensciencias.2088**

La revista *Enseñanza de las Ciencias: revista de investigación y experiencias didácticas* (ISSN: 2174-6486; 0212-4521) es publicada por el Institut de Ciencies de l'Educacio de la Universitat Autonoma de Barcelona (España).

H Index: 6
Factor de impacto: 0,302 en el año 2015 dentro de Journal Citations Reports.

Posición en su categoría:

211 (Q4) de 231 en la categoría Education & Educational Research dentro de Journal Citations Reports en el año 2015.

Cuenta con el sello de calidad de la FECYT y está indexada en las siguientes bases de datos:

- JCR-WOS SSCI (ISI)
- Scimago
- Scopus
  CARHUS +
- CIRC
- DIALNET plus
- DICE
- ERIH PLUS
- Google Scholar
- IRESIE
- Latindex (Catálogo)
- MathEduc

4) **Ouariachi, T., Olvera-Lobo, M.D., & Gutiérrez-Pérez, J. (2017). "Analyzing climate change communication through online games: development and application of validated criteria".** ***Science Communication, 39*** **(1), 10-44. DOI: 10.1177/1075547016687998**

La revista *Science Communication* (ISSN: 10755470; 15528545) es publicada por SAGE Publishing (Estados Unidos).

H Index: 40

Factor de impacto: 1,820 en el año 2015 dentro de Journal Citations Reports.

Posición en su categoría:

14 (Q1) de 79 en la categoría Communication dentro de Journal Citations Reports en el año 2015.

Está indexada en las siguientes bases de datos:

- Abstract Journal of the Educational Resources Information Center (ERIC)
- AgBiotech News and Information
- AgBiotechNet
- CAB Abstracts (Index Veterinarius, Veterinary Bulletin)
- CAB Abstracts Database
- CAB Health
- CABI: Forestry Abstracts
- CABI: Global Health
- CABI: Nutrition Abstracts and Reviews Series A
- Clarivate Analytics: Current Contents - Physical, Chemical & Earth Sciences
- ComAbstracts
- Corporate ResourceNET - Ebsco
- Current Citations Express
- EBSCO: Communication Abstracts
- ERIC Current Index to Journals in Education (CIJE)
- EServer.org
- Horticultural Science Abstracts

- Leisure, Recreation and Tourism Abstracts
- MasterFILE - Ebsco
- Plant Breeding Abstracts
- Poultry Abstracts
- ProQuest: Applied Social Science Index & Abstracts (ASSIA)
- ProQuest: CSA Sociological Abstracts
- SafetyLit
- Scopus
- Social SciSearch
- Social Sciences Citation Index (Web of Science)
- Social Services Abstracts
- Soils and Fertilizers
- Standard Periodical Directory (SPD)
- TOPICsearch - Ebsco
- World Agricultural Economics and Rural Sociology Abstracts (in CAB Abstracts Database)

5) **Ouariachi, T., Olvera-Lobo, M.D., & Gutiérrez-Pérez, J. (2017). "Gaming climate change: assessing online climate change games targeting youth produced in Spanish".** ***Procedia - Social and Behavioral Sciences, 237*** **(21), 1053-1060. DOI: 10.1016/j.sbspro.2017.02.154**

La revista *Procedia - Social and Behavioral Sciences* (ISSN: 1877-0428) es publicada por la editorial Elsevier (Países Bajos).

H Index: 22

Conference Proceedings Citation Index- Social Science & Humanities (CPCI-SSH)

Posición en su categoría:

Categorías de Web of Science: Business; Social Sciences, Interdisciplinary.

Está indexada en las siguientes bases de datos:

- Conference Proceedings Citation Index

6) **Ouariachi, T., Gutiérrez-Pérez, J., & Olvera-Lobo, M.D. (2017). "The impact of online games on awareness, knowledge and attitudes: the case of 2020 Energy", in** ***Innovación Universitaria: digitalización 2.0 y Excelencia en contenidos,*** **Editorial McGraw Hill. ISBN- 978-84-48612-71-9 (in press).**

Editorial de prestigio de ámbito internacional (10 de 258 en el ranking SPI (Scholarly Publishers Indicators in Humanities and Social Sciences)

AGRADECIMIENTOS

La presente tesis doctoral es el resultado de un recorrido de aprendizaje profesional y personal, una gran experiencia. Para llegar a su culminación, he contado con el apoyo de una serie de personas a las que quisiera agradecerles su ayuda.

En primer lugar a las personas que han dirigido esta tesis. A la Dra. María Dolores Olvera Lobo por haber aceptado desde un primer momento ser mi tutora sin conocernos previamente, formarme como investigadora y poner su experiencia al servicio de este trabajo. Igualmente, al Dr. José Gutiérrez Pérez, quien además de haber codirigido esta tesis doctoral, me ha iniciado en algunas de las metodologías empleadas, aportando también sus conocimientos a mi trayectoria como investigadora. A pesar de los kilómetros que nos han separado en largos periodos, ambos han mantenido una comunicación excelente. Además, cada uno de ellos desde una disciplina del conocimiento distinta, por un lado la comunicación científica y por otro la educación ambiental, me han dado unas orientaciones cruciales que han aportado una gran riqueza y valor interdisciplinar a esta investigación.

Quisiera expresar mis agradecimientos a los profesores que han supervisado mis estancias académicas, tanto en Estados Unidos como en los Países Bajos, por su acogida y cantidad de conocimientos y experiencias facilitadas. Igualmente a los docentes de los institutos en Madrid (Jaoine Pozuelo) y Washington D.C. (Lida Salmani) por su entusiasmo y por haber facilitado que el proyecto de intervención con los estudiantes se hiciera realidad. A los expertos que participaron en el método Delphi también quisiera agradecerlas que hayan formado parte del estudio.

A mi amiga la Dra. Lourdes López por sus ánimos y asesoramiento; a Laura y Mariasun por echar un cable y hacer el camino menos solitario. Y gracias a la Dra. Lidia Peralta (mi tía) por haberme animado a iniciar esta gran aventura y darme buenos consejos.

Por último, no por ello menos importante, en lo que se refiere al ámbito más personal me gustaría agradecerle también al resto de mi familia su ánimo durante todos estos años, a mis abuelos, a mi hermano, y sobre todo a mis queridísimos padres, por facilitar que continúe formándome, por su infinito amor y apoyo. Y una mención especial para mi pareja, Chris Wind, fuente de inspiración, por su cariño, paciencia e incondicional ayuda.

RESUMEN

El cambio climático se ha convertido en uno de los problemas centrales de la sociedad del siglo XXI. El Panel Intergubernamental para el Cambio Climático (IPCC) ya confirmó por primera vez en 2007 que las actividades humanas, como la quema de combustibles fósiles o la deforestación, son muy probablemente las responsables del cambio climático. Nos enfrentamos por tanto a un fenómeno que representa la punta del iceberg de un modelo de económico insostenible, basado en el crecimiento infinito sobre recursos finitos, que requiere de una nueva forma de acción social, para la que las nuevas generaciones están llamadas a actuar (Chaparro-Escudero, 2013; Klein, 2015).

Abordar el cambio climático desde las ciencias naturales y físicas no es suficiente. El cambio climático es también un problema social, por lo que estudiar este fenómeno desde las ciencias sociales es tarea fundamental para los investigadores ante la necesidad de acción ciudadana para adoptar medidas de mitigación y adaptación. En esta transformación social que requiere la lucha contra el cambio climático, los jóvenes, nuestros futuros líderes, están llamadas a actuar. Las nuevas generaciones están bien posicionadas para desencadenar un cambio ambicioso, adoptando actitudes y comportamientos responsables desde edades tempranas e influenciando la decisión de sus padres. Sin embargo, las encuestas muestran que los jóvenes están incluso menos concienciados sobre el medioambiente que sus padres y menos comprometidos a tomar acciones medioambientalmente responsables (Bofferding y Kloser, 2015; Fielding y Head, 2012; Partridge, 2008).

Diversos estudios han revelado que la manera en la que se ha comunicado el cambio climático hasta ahora no ha sido efectiva. Algunos de los desafíos que caracterizan el paradigma comunicativo clásico en relación con el cambio climático tienen que ver con la responsabilidad de los medios de comunicación en la denominada "lógica de la distribución" y la transmisión unidireccional de los mensajes, que transforma a la audiencia en consumidores pasivos de la información (Aparici y Silva, 2012), así como con la propia producción de contenido informativo sobre este tema, con escasa contextualización y un elevado tono negativo-alarmista, provocando apatía y parálisis en lugar de motivación para tomar acción (Díaz-Nosty, 2013; González-Gaudiano, 2012; León, 2014; Meria-Cartea, 2008; Moser, 2010). De la misma manera, los programas educativos convencionales siguen poniendo énfasis en la alfabetización científica en lugar de cambiar los métodos de transmisión del conocimiento, basados también en modelos comunicativos unidireccionales. Estos programas deben adaptarse a los nuevos estilos de procesamiento de información y motivaciones de los jóvenes, además de añadir una perspectiva más crítica a la educación medioambiental, abriendo espacios de reflexión y debate sobre posibles alternativas de cambio (Bello-Benavides et al., 2017; González-Gaudiano y Meira, 2009).

Por lo tanto, existe una necesidad urgente de buscar nuevas estrategias para fomentar la concienciación y la acción social, capaces de conectar con la llamada "generación interactiva" (Aguaded-Gómez, 2011) o "nativos digitales" (Prensky, 2001). La gamificación en general, y los juegos online en particular, pueden ofrecer esas posibilidades: gracias a la interactividad y a su capacidad de inmersión, pueden facilitar un aprendizaje experimental, transformando a consumidores pasivos de información en jugadores con un rol activo, más preparados para absorber nueva información y simular circunstancias que no son posibles en la vida real (Gee, 2004; Mendler de Suarez, et al.,

2012). Los juegos online sobre cambio climático han experimentado su mayor progreso en los últimos diez años, (Reckien y Eisenack, 2013), con ejemplos como *Clim'Way* (2010), *BBC Climate Challenge* (2010), *EnerCities* (2011), y *CityOne* (2011). Se trata de juegos disponibles en Internet que persiguen objetivos comunicativos y educativos, sin excluir la diversión, que se centran en el cambio climático o en temas relacionados con este fenómeno; se consideran "juegos serios" porque su propósito va más allá del entretenimiento (Frasca, 2007). La aplicación de las dinámicas y mecánicas del juego a contextos que no son juegos, como lo son las instituciones educativas, para motivar y comprometer a la gente para alcanzar determinados objetivos, ha recibido el nombre de gamificación, un fenómeno que también ha ido recibiendo más atención en los últimos años (Marczewski, 2012).

Teniendo en cuenta el incremento de actividades gamificadas en las instituciones educativas, y el desarrollo de juegos online sobre cambio climático, existe la necesidad de analizar su naturaleza educomunicativa. Sin embargo, estudios previos no ofrecen un instrumento de análisis holístico de elementos comunicativos (desde una perspectiva narratológica y ludológica) y educativos; y en segundo lugar, prestan atención principalmente a los videojuegos de habla inglesa, mientras que los videojuegos en español y producidos en países no anglosajones han recibido escasa consideración a pesar de su proliferación (Katsaliaki y Mustafee, 2014; Reckien y Eisenack, 2013; Wu y Lee, 2015). También existe la necesidad de analizar el impacto de estos juegos y conocer cómo funcionan en la práctica. Existe poca evidencia empírica para probar su efectividad, y los resultados son hasta ahora contradictorios, algunos mostrando efectos positivos y otros efectos limitados o nulos (Soekarjo y van Oostendorp, 2015; Yang et al., 2016).

En este contexto se desarrolla el presente estudio que plantea como objetivo general explorar el potencial de los juegos online sobre cambio climático como herramientas educomunicativas para comprometer a los jóvenes en la lucha contra el cambio climático. Para estudiar su potencial, se establecen los siguientes objetivos específicos con sus correspondientes métodos de investigación:

Obj. 1) Desarrollar y proponer una serie de criterios validados que permitan analizar las características comunicativas y educativas de los juegos online sobre cambio climático. Para alcanzar este objetivo, hemos usado un proceso de recogida de opiniones grupales, consensuadas y fidedignas, mediante el método Delphi, un proceso sistemático, interactivo y colaborativo encaminado a la obtención de consenso a partir de juicios de expertos. En nuestro caso, hemos contamos con un panel de 13 expertos de España y el extranjero, y hemos llevado a cabo tres ciclos de consulta a los expertos, empezando con una propuesta cualitativa abierta y concluyendo con un instrumento final más cerrado y pautado, hasta conseguir estabilidad en resultados y consenso en la decisión final.

Obj. 2) Analizar las caracterísitcas comunicativas y educativas de los juegos online sobre cambio climático destinados a los jóvenes mayores de 12 años, producidos en España (muestra 1) o en español (muestra 2). Para identificar las muestras de estudio, se ha llevado a cabo una búsqueda web en el periodo de Mayo a Julio de 2015; se han seleccionado aquellos juegos que se localizan en una plataforma web y se juegan a través de internet, son de acceso abierto y gratuito, persiguen fines comunicativos y educativos sin tener que excluirla diversión, centran su temática en el cambio climático

o temas afines, son producidos en España o en idioma español. Para analizar los juegos seleccionados, se ha hecho uso de los criterios validados mediante el método Delphi, y se han aplicado técnicas de la narratología / ludología y un análisis de contenido cualitativo.

Obj. 3) Examinar el impacto de un juego sobre la concienciación, conocimientos y actitudes con respecto al cambio climático y el ahorro energético sobre una muestra de estudiantes de secundaria. Para alcanzar este objetivo se ha empleado un pre-test y pos-test sobre una muestra de 108 estudiantes de entre 12 y 14 años (58 españoles y 50 estadounidenses) divididos aleatoriamente en grupo experimental (juega) y grupo control (no juega). Los cuestionarios online cuentan con 17 ítems que incluyen preguntas abiertas, multi-respuesta y de escala para examinar su concienciación, conocimientos y actitudes antes y después de la intervención. Para la intervención del grupo experimental se ha usado el juego *2020 Energy*. Los cuestionarios se han complementado con la observación durante el juego (expresiones faciales, conversaciones entre compañeros y dudas que surgen) y un grupo de discusión para recoger datos cualitativos acerca de su interacción (misiones preferidas, emociones, lecciones).

Los resultados de este estudio nos ha permitido diseñar un instrumento de análisis y evaluación de juegos online sobre cambio climático con 51 criterios consensuados, los cuales se dividen en cinco dimensiones: identificación, narrativa, contenidos, jugabilidad y didáctica. La aplicación de estos criterios sobre una muestra de juegos producidos en España y juegos disponibles en español muestran tendencias positivas en la comunicación del cambio climático, tal y como recomiendan autores como Sheppard (2012): a) hazlo local –para evitar una distancia psicológica-, b) hazlo visual –para hacer del cambio climático algo real y memorable-, y c) hazlo relacional –para ofrecer un sentido de confianza en las capacidades individuales y colectivas para hacer frente al cambio climático-.

La mayoría de los juegos analizados muestran a ciudadanos corrientes en los que el jugador toma decisiones sostenibles en su casa, comunidad o territorios a gestionar para reducir los gases de efecto invernadero, y presentan también un discurso positivo y de empoderamiento, a través de las historias, mensajes centrados en acciones posibles, y la jugabilidad (retroalimentación constante, elogios y recompensas). Existen también buenos ejemplos de juegos que combinan las dimensiones globales, nacionales y locales, y llaman a la movilización social o a poner presión sobre los políticos. Sin embargo, también se han identificado algunos aspectos que podrían mejorarse: falta de contenidos sobre adaptación al cambio climático, falta de temáticas que promuevan el pensamiento crítico y la reflexión tales como la justicia social, la solidaridad, la cooperación, o el decrecimiento, poca integración con redes sociales, así como el riesgo de enmascarar un *advergame* en un juego educativo, entre otros. En cuanto a las características educativas, nuestra muestra de juegos facilita el desarrollo de la mayoría de las competencias asignadas por la LOMCE (2015), ofrece posibilidades para usarse en distintas materias y disciplinas, para trabajar en grupo y como instrumento de evaluación de los docentes. Existen buenos ejemplos en los que se abren espacios de debate y reflexión. Sin embargo, la mayoría de los juegos no ofrecen guías didácticas que ayuden a los docentes a implementar el juego en clase y pocos son los disponibles para estudiantes con discapacidad.

Según nuestro estudio empírico en el que examinamos el impacto del juego *2020 Energy* en la concienciación, conocimiento y actitudes de estudiantes de secundaria, los resultados muestran que no hay diferencias estadísticamente significativas entre grupo experimental y control. Posibles explicaciones tienen que ver con que la muestra ya era bastante simpatizante con el medio ambiente; el riesgo de "deseabilidad social" al responder las preguntas; o las críticas lanzadas por los estudiantes en torno al su interacción con el juego, tales como gráficos pobres o la falta de desafíos y otro tipo de mecánicas de juego.

Por lo tanto, este estudio concluye que el potencial de los juegos online sobre cambio climático depende no sólo de su naturaleza educomunicativa, sino también de la mentalidad de los jugadores y la manera en la que los objetivos comunicativos y de aprendizaje se canalizan a través de su diseño conceptual. Los resultados de esta tesis muestran que a pesar de que los juegos muestren tendencias positivas en la comunicación del cambio climático, en la práctica hay otros factores importantes que contribuyen a su efectividad.

La presente tesis doctoral sigue la modalidad de publicaciones. Los resultados y conclusiones aquí resumidas se ven reflejadas en detalle en las siguientes publicaciones:

1) Ouariachi, T., Gutiérrez-Pérez, J., y Olvera-Lobo, M.D. (2017) "Criterios de evaluación de juegos online sobre cambio climático: aplicación del método Delphi para su identificación". *Revista Mexicana Investigación Educativa, 22* (73) (en prensa) → objetivo 1
2) Ouariachi, T., Olvera-Lobo, M.D. & Gutiérrez-Pérez, J., (2017). "Analysis of individual online climate change games targeting youth: proposing a checklist and exploring opportunities". *Revista Electrónica de Investigación Educativa* (REDIE), 19 (2) (in press) → objetivo 2
3) Ouariachi, T., Olvera-Lobo, M.D y Gutiérrez-Pérez, J. (2017). "Evaluación de juegos online para la enseñanza y aprendizaje del cambio climático". *Enseñanza de las Ciencias: revista de investigación y experiencias didácticas*, *22* (73), 193-214. DOI: 10.5565/rev/ensciencias.2088 → objetivo 2
4) Ouariachi, T., Olvera-Lobo, M.D., & Gutiérrez-Pérez, J. (2017). "Analyzing climate change communication through online games: development and application of validated criteria". *Science Communication, 39* (1), 10-44. DOI: 10.1177/1075547016687998 → objetivo 2
5) Ouariachi, T., Olvera-Lobo, M.D., & Gutiérrez-Pérez, J. (2017). "Gaming climate change: assessing online climate change games targeting youth produced in Spanish". *Procedia - Social and Behavioral Sciences, 237* (21), 1053-1060. DOI: 10.1016/j.sbspro.2017.02.154 → objetivo 2
6) Ouariachi, T., Gutiérrez-Pérez, J., & Olvera-Lobo, M.D. (2017). "The impact of online games on awareness, knowledge and attitudes: the case of 2020 Energy", in *Innovación Universitaria: digitalización 2.0 y Excelencia en contenidos*, Editorial McGraw Hill. ISBN- 978-84-48612-71-9 (in press) → objetivo 3

Así, sirva esta tesis doctoral como una reflexión y un primer acercamiento a un tema de estudio emergente que merece más atención.

REFERENCIAS

Aguaded-Gómez, I. (2011). Children and young people: the new interactive generations. *Comunicar*, *36*(XVIII), 7-8. doi:10.3916/C36-2011-01-01

Aparici, R., y Silva, M. (2012). Pedagogy of Interactivity. *Comunicar*, *38*(XIX), 51-58. doi:10.3916/C38-2012-02-05

Bello-Benavides, L.O., Alatorre-Frenk, G. y González-Gaudiano, E. (2017). La educación ambiental en el Bachillerato Tecnológico. Un análisis crítico. Revista Interamericana de Educación de Adultos, 112-129.

Bofferding, L., y Kloser, M. (2015). Middle and high school students' conceptions of climate change mitigation and adaptation strategies. *Environmental Education Research*, *21*, 275-294. doi:10.1080/13504622.2014.888401

Chaparro-Escudero, M. (2013). Construcción de un imaginario perverso. La comunicación del desarrollo. *Telos, 94*, 31-42.

Díaz-Nosty, B. (2013). Aproximación a la construcción interdisciplinar y de un nuevo paradigm: Comunicación, cambio climático y crisis sistemática. *Razón y Palabra*, *84*, 99-119. doi:10.4185/RLCS-64-2009-808-99-119

Fielding, K., y Head, B. W. (2012). Determinants of young Australians' environmental actions: The role of responsibility attributions, locus of control, knowledge and attitudes. *Environmental Education Research*, *18*, 171-186. doi:10.1080/13504622.2011.592936

Frasca, G. (2007). *Play the message: Play, game and video game rhetoric* (Unpublished doctoral dissertation). IT University of Copenhagen, Copenhagen, Denmark. Retrieved from http://www.powerfulrobot.com/Frasca_Play_the_Message_PhD.Pdf

Gee, J. P. (2004). *Lo que nos enseñan los videojuegos sobre el aprendizaje y el alfabetismo*. Archidona, Spain: Aljibe.

González-Gaudiano, E. (2012). Educación y cambio climático: aportes de las representaciones sociales. *Revista Contemporânea de Educação*, 7(14), 369-397.

González-Gaudiano, E. y Meira-Cartea, P.A. (2009). Educación, comunicación y cambio climático. *Trayectorias, 11*(29), 6-38.

Katsaliaki, K., y Mustafee, N. (2014). Edutainment for sustainable development: A survey of games in the field. *Simulation & Gaming*. Advance online publication. doi:10.1177/1046878114552166

Klein, N. (2015).This changes everything: capitalism vs. the climate. New York: Simon & Schuster Paperbacks.

León, B. (Coord.). (2014). *El periodismo ante el cambio climático: Nuevas perspectivas y retos*. Barcelona, Spain: Editorial UOC.

LOMCE - *Ley Orgánica para la Mejora de la Calidad Educativa* de 2015. Orden ECD/65/2015, de 21 de enero

Meira-Cartea, P.A. (2008). *Comunicar el cambio climático. Escenario social y líneas de actuación.* Madrid: Ministerio de Medio Ambiente y Medio Rural y Marino-Organismo Autónomo de Parques Nacionales.

Mendler de Suarez, J., Suarez, P. y Bachofen, C. (2012). *Games for a New Climate: Experiencing the Complexity of Future Risks. Boston:* Boston Univ., The Frederick S. Pardee Center for the Study of the Longer-Range Future.

Moser, S. C. (2010). Communicating climate change: History, challenges, process and future directions. *WIREs Climate Change*, *1*, 31-53. doi:10.1002/wcc.011

Partridge, E. (2008). From ambivalence to activism: Young people's environmental views and actions. *Youth Studies Australia*, *2*, 18-25.

Prensky, M. (2001). Digital natives, digital immigrants. *On the Horizon*, *9*(5), 1-6. doi:10.1108/10748120110424816

Reckien, D., y Eisenack, K. (2013). Climate change gaming on board and screen: A review. *Simulation & Gaming*, *44*, 253-271. doi:10.1177/1046878113480867Reeves et al., 2015

Sheppard, S.R.J. (2012). *Visualizing climate change: A guide to visual communication of climate change and developing local solutions*. Abingdon, Oxon: Routledge.

Soekarjo, M., y van Oostendorp, H. (2015). Measuring Effectiveness of Persuasive Games Using an Informative Control Condition. *International Journal of Serious Games*, 2(2).

Wu, J., y Lee, J. (2015). Climate change games as tools for educational and engagement. *Nature Climate Change*, *5*, 413-418. doi:10.1038/NCLIMATE2566

Yang, J.C., Lin, Y.L., y Liu, Y.C (2016). Effects of locus of control on behavioral intention and learning performance of energy knowledge in game-based learning. *Environmental Education Research*, 1-14. doi:10.1080/13504622.2016.1214865

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PART I

FRAMEWORK AND BACKGROUND

CHAPTER 1: INTRODUCTION

Climate change is an inevitable and pressing global challenge with long-term implications for all countries. In 2007, the Intergovernmental Panel on Climate Change achieved the consensus that global warming is unequivocal and very likely due to human activities, such as burning fossil fuels or deforestation, that lead to increased greenhouse gas concentration in the atmosphere. Without going further, Spain is highly vulnerable to climate change: in the last century, temperatures have increased 1.5ºC, representing 0.5ºC more than the world average; glaciers in the Pyrenees have lost vast volume, sea level has risen, and desertification has expanded. Negative consequences can already be observed in people's quality of life, health and economy (Martínez-Valderrama et al., 2016). We are facing therefore a phenomenon that represents the tip of the iceberg of an unsustainable economic model, based on infinite growth on a planet where resources are finite, which requires social transformation (Chaparro-Escudero, 2013; Klein, 2015). That means that addressing climate change from a natural and physical sciences perspective is not enough. Climate change is also a social problem, so studying this phenomenon from a social sciences perspective is essential, answering questions such as how we can change our culture of consumption or how we can respond to extreme weather events.

The social transformation needed to fight climate change requires the engagement of young people, our future leaders. The new generation is potentially well positioned to trigger an ambitious change, adopting sustainable attitudes and behaviours in energy use from early ages and influencing their parents' decisions. Despite the urgency of the matter, research has shown that awareness and commitment are still limited (Bofferding & Kloser, 2015): youth is even less concerned about the environment than older age-groups and less likely to engage in environmentally responsible actions (Fielding & Head, 2012; Partridge, 2008).

Superficial conclusions such as young people "do not care" or "do not get it" can rest importance to the need to better analyze the way climate change has been communicated, received and perceived until now (Meira-Cartea, 2011; Moser & Dilling 2011). Science communication has for a long time pointed to the information deficit model (little amount of information available) as the main problem (Nisbet & Scheufele, 2009). In fact, in Spain three polls carried out in 2008-2012 revealed a sharp drop in the amount of information received both through personal conversations and the media (Heras-Hernández et al., 2016). Recently, concerns are also related with the way climate change information has been conveyed: scholars acknowledge the limitations of conventional media in delivering information, such as the one-way transmission of messages, which transforms the audience into passive consumers of information; the lack of contextualization, which provokes confusion with other environmental issues; the focus on institutional responses and disagreements among the international community, ignoring alternative message framings with issues such as health, employment and security; and the negative and alarmist tone of the content mostly focusing on impacts, which instead of motivating people to take action often evokes paralysis or apathy (Aparici & Silva, 2012; Díaz-Nosty, 2013; González-Gaudiano, 2012; León, 2014; Moser, 2010).

There are also concerns related with how climate change has been communicated at schools, putting emphasis on increasing scientific literacy (González-Gaudiano &

Meira, 2009). Since the second half of the 20th century, serious critics to the pedagogical model have been raised because of its methods for knowledge transfer, based on unidirectional communicative models that divide transmitter and receiver of the information (Aparici & Silva, 2012). Critics also apply to the lack of interdisciplinary nature and critical thinking (Bello-Benavides et al., 2017); education should be understood as a "social process" instead of "curricular process" which empowers young people to think critically and reflect (González-Gaudiano, 2007).

Scholars and practitioners have called for new strategies to be found, capable of connecting with targeted audiences such as the so-called "interactive generation" (Aguaded-Gómez, 2011) or "digital natives" (Prensky, 2001). Gamification in general, and online games in particular, might offer these possibilities: they can provide experiential learning, transforming passive consumers of information into active players who absorb new information more readily and simulate unfamiliar circumstances that are not possible in real life (Gee, 2004; Mendler de Suarez, et al., 2012). By online games we understand video games that use computer technology, allowing players to interact with the machine in real time and action to take place in a visual format, with a unique feature in that they are accessible via a Web browser and available on the Internet (Tejeiro & Pelegrina, 2003). Online climate change games would be then games available on the Internet specifically themed around climate change and/or topics related to this phenomenon, with communicative and educational purposes, which does not exclude that they can involve some degree of fun and entertainment.

The first climate change game was designed more than 30 years ago, as a board game that modelled increasing levels of CO2 in the atmosphere (Wu & Lee, 2015), and since then climate change games have increased and diversified: card games such as *Keep Cool*, where players represent groups of countries that negotiate economic growth and climate change mitigation; simulations based on peer-reviewed scientific data that allow for the manipulation of variables such as energy consumption and population growth to model the effects on world climate, like those collected on the website *Climate Interactive*; or mobile games like *Climate Mission 3D*, where players learn how to reduce their carbon footprint as they play a series of mini-games. In the past 10 years, climate change games have experienced most progress (Reckien & Eisenack, 2013), especially in an online format, with examples like *Clim'Way* (2010), *BBC Climate Challenge* (2010), *EnerCities* (2011), and *CityOne* (2011).

Online climate change games can be considered "serious games" because their purpose exceeds pure entertainment (Frasca, 2007). Their goals can be summarized in (a) making players aware of the challenges associated with global warming, (b) providing knowledge and understanding with the issue of climate change, and (c) encouraging players to take actions and develop solutions (Reckien & Eisenack, 2013; Wu & Lee, 2015). The application of game mechanics to non-game contexts, such as educational institutions, to engage people, has received the name of "gamification", a phenomenon that has also received substantially more attention in the last years (Marczewski, 2012).

Taking into account the increased number of gamified activities in schools and the development of online climate change games, we need to better understand the nature of these games. On the one hand, their communicative nature: how these games are transmitting climate change issues through their narratives and contents, the meanings hidden behind the design, and the preferred techniques chosen by producers; on the

other hand, their educative nature and the extent to which they can be applied to formal educational contexts. In addition, we need to better understand the impacts of these types of games in changing young people´s awareness, knowledge and attitudes. Understanding how online climate change games "work" in theory and in practice will contribute to assess the potential of these educommunicative tools -understood here as communication media used in the school curriculum (Aparici, 2010; Cooper, 2011; Moser, 2010)- to engage youth in the fight against climate change.

As observed, the topic of this thesis is interdisciplinary, combining the fields of climate change, communication, education, and games. Studying a subject in its wider context can be enlightening and enriching. The motivation of this approach is also derived from the interdisciplinary academic background of the researcher and her previous working experience in the field.

With regards to the structure of this thesis:

- Part I presents the framework and background of this work: Chapter 1 serves as an introduction; Chapter 2 sets the objectives, the scope and the scientific and social relevance of the study; and Chapter 3 summarizes the theoretical and methodological approaches applied in the thesis.
- Part II consists of the main component, presenting the publications with the results[1]. It is divided into two chapters which represent the two different types of studies carried out for this thesis: Chapter 4 focuses on the development of the set of criteria (article 1; written in Spanish) and on analyzing the communicative and educative nature of online climate change games from different perspectives: article 2 presents a qualitative analysis of the communicative features of five games produced in Spain; article 3 expands the evaluation of these five games to both communicative and educative features (written in Spanish); article 4 analyzes only communicative features of a sample of 15 games produced in Spain, applying content analysis, narratology, and ludology techniques; and in article 5 we examine communicative and educative elements (also using applying content analysis, narratology, and ludology techniques) of a sample of 24 games targeting youth in Spanish language, independently of whether the production is from Spain or another country. Chapter 5 focuses on analyzing the impact of a selected game; we include here article 6, which presents an empirical study that examines the impact of the serious game *2020 Energy* in changing students´ climate change and energy-related awareness, knowledge and attitudes.
- Finally, in Part III we discuss the findings of these publications, presenting the main conclusions and relevant issues which remain to be explored suggesting future research. We add an extra chapter of case studies to share the experiences obtained during the academic mobility to the universities in the United States and The Netherlands.

[1] In-text citation and references have been maintained according to the norms of each of the journals where the articles are inserted

CHAPTER 2: OBJECTIVES, STUDY DELIMITATION AND RELEVANCE

The general objective of the work presented here is to explore the potential of online climate change games as educommunicative tools to engage youth in the fight against climate change. We have defined potential as: 1) the ability to communicate climate change, facing the challenges posed by traditional media, and the ability of using this tool in formal education contexts, considered as key places where young people consume information, facing the challenges posed by traditional pedagogical model; and 2) the ability to have an impact on young people´s awareness, knowledge and attitudes. In order to asses this potential, we establish the following specific objectives:

1. To develop and propose a set of validated criteria that allow us to analyze communicative and educative features of online climate change games.

2. To analyze communicative and educative features of online climate change games targeting young people (12+):
a) produced in Spain
b) produced in Spanish language

3. To examine the impact of a game on students´ awareness, knowledge, and attitudes towards climate change and energy issues.

Based on the literature review exposed below, we hypothesize that online climate change games have the potential to engage young people in the fight against climate change: first of all, we maintain that these games contribute to an effective communication of the issue, facing the limitations posed by traditional media and traditional instructional methods; secondly, we maintain that playing online climate change games has a positive impact on awareness and knowledge, and a limited effect on behavioural intentions.

We have delimited the study to online games because the majority of climate change games are available in this format. As Reckien & Eisenack (2013) affirm, in the last decade, climate change games have experienced the most progress especially in digital versions.They are also chosen for their distinct features as a digital tool, popularity and generalized use among youth, and possibility to be used by teachers in computer labs at their schools since we look at games as educommunicative tools.

The reason why we focus on adolescents aged over 12 years-old is because they have more developed cognitive processes than younger children, allowing them to have more ability for complex thoughts, express their feelings better, and cultivate a stronger sense of right and wrong. Another reason, as stated in the introduction, is that young people are well positioned to trigger an ambitious and long-term societal change, adopting sustainable attitudes from early ages and influencing their parents' decisions. Focusing on a specific segment of the population is also necessary as suggested by social marketing for the design and analysis of communication efforts.

The research is also delimited to games that have been produced in Spain or in Spanish language because not much empirical research is available to date researching games produced in non-English countries and languages (Katsaliaki & Mustafee, 2014; Reckien & Eisenack, 2013; Wu & Lee, 2015). Spain for instance is currently

experiencing its video game development "golden age"; it ranks fourth in Europe and ninth in the world (DEV, 2015). A growing number of multinationals are founding studios in Spain, and creativity of Spanish young professionals is being supported by universities, which have established training programs in the sector in recent years (DEV, 2015). This study aims to bridge these gaps.

The research presented here has scientific and social relevance. Taking into consideration that the average young person in a country with a strong gaming culture will have spent 10.000 hours playing online games by the age of 21 (McGonigal, 2011), these tools are worth exploring. First of all, the study offers a set of validated criteria to analyze communicative and educative features of online climate change games. Even though discussions have begun on the analysis of serious games in general (Liarakou et al., 2012; Liu & Ding, 2009; Martí-Parreño et al., 2015; Mitgutsch & Alvarado, 2012), and on the analysis of sustainability and climate change games in particular (Katsaliaki & Mustafee, 2014; Reckien & Eisenack, 2013; Wu & Lee, 2015), previous research in this field mostly focuses on general characteristics that can help identify the game without further going into details. In practice, the criteria proposed in this study offer guidelines for docents, providing a list of important indicators to take into account when selecting appropriate games as pedagogical resources; and for game developers, providing hints to design new games on climate change. The illustration and demonstration of the criteria through the analysis of available climate changes games on the web is also valuable and of interest in order to examine trends and preferred techniques within this class of games. The findings can also serve as a starting point to propose similar evaluation instruments oriented to serious games focused in other topics.

Secondly, the study contributes to reinforce conclusions on the potential of these educommunicative tools by testing the impact of an online climate change and energy game on a sample of adolescents. There is limited empirical evidence currently available to prove effectiveness of serious games in general, and online climate change games in particular, and the findings are so far contradictory, some revealing positive effects on awareness, knowledge, attitudes or behaviors, and others just limited or no effects (Soekarjo & van Oostendorp, 2015; Yang et al., 2016). The results of this study contribute to an emerging field of study and provide some recommendations for designing these types of games and implementing them in class. According to Mitgush & Alvarado (2012), not only the players' mindset and the contextual framing of the play situation influences the impact of serious games, but also the way the purpose of games is channeled through their conceptual design.

CHAPTER 3: THEORETICAL AND METHODOLOGICAL APPROACHES

This thesis is characterized as interdisciplinary, exploratory, and evaluative. It integrates different theoretical approaches and it applies qualitative and quantitative methods aiming at the triangulation of data.

Since 2011, when Espen Aarseth from *IT University of Copenhagen* founded the first academic journal to study video games, *Game Studie*s, several approaches to look at games have been proposed from several scientific disciplines. These are some of them:

1. Design, formal dimension, and significance studies: game design theory (Salen & Zimmerman, 2004), narratology (Murray, 1999), ludology (Juul, 2005), or procedural content generation (Shaker et al., 2016).

2. Sociocultural dimension and video game reception studies: education and online games studies (Gee, 2004), cultural and reception studies (Taylor, 2006), or psychosocial effects (Egenfeldt-Nielsen et al., 2008).

This thesis is positioned within both groups (Figure 1). Objective 1 (to develop and propose a set of validated criteria that allow us to analyze communicative and educative features of online climate change games) and Objective 2 (to analyze communicative and educative features of online climate change games targeting young people) corresponds to the group of design, formal dimension and significance studies, while Objective 3 (examine the impact of a game on students´ awareness, knowledge, and attitudes towards climate change and energy issues) corresponds to the group of sociocultural dimension and video game reception studies.

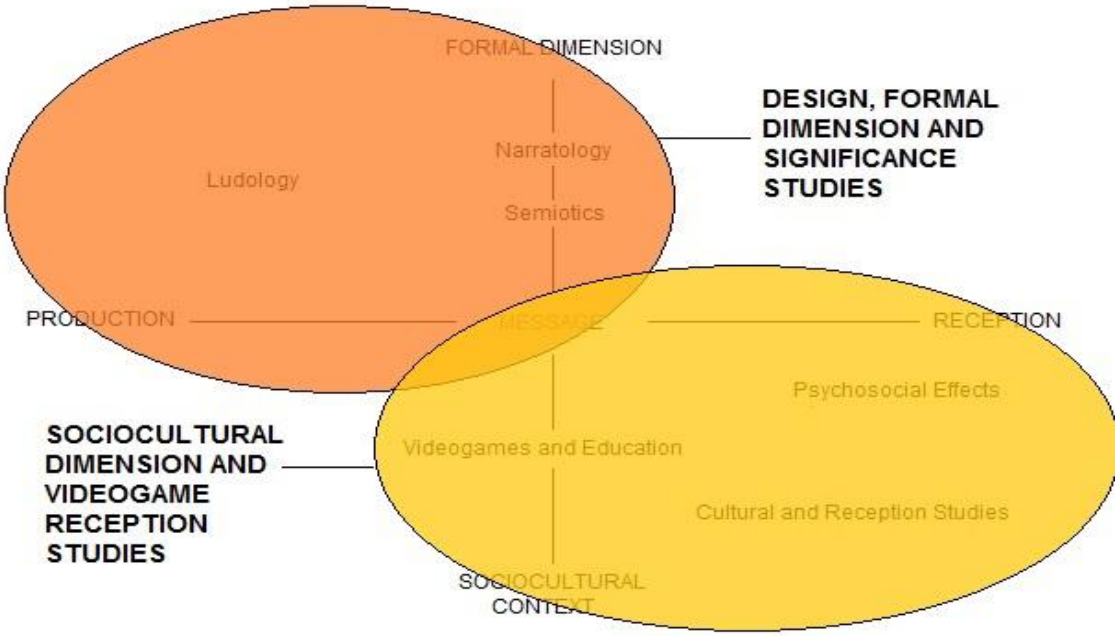


Figure 1: Study's theoretical positioning: representation of theoretical perspectives for game analysis integrated into communication sciences study delimitation around five variables: production, reception, formal dimension, contextual dimension, and message. *Source*. Adaptation from Pérez-Latorre (2010).

The first category has literature or cinema studies as the main antecedent, in which analyses are focused on the work itself, independently of the reception context (Pérez-Latorre, 2010). In this domain, scholars have disagreed over time on how to approach video game analysis; the spectrum ranges from the affirmation of the new possibilities of storytelling to the denial of the narrative quality of video games; the disagreement has been called "narratology versus ludology debate" (Frasca, 2007).

Narratology refers to the branch of knowledge that deals with the structures and function of narrative (Murray, 1999); narratologists believe that games should be understood as a storytelling medium or a novel form of narrative and therefore should be analyzed using theories of narrative. They see video games as a broad form of narrative expression such as novels or movies. After Janet Murray (1999) published *Hamlet on the Holodeck*, in which she discusses the technical possibilities and the new ways of storytelling in the cyber age, several researchers started taking the same approach by studying online games as a narrative form. Ludology defends the study of structures and features of games on their own terms, not as a form of narrative expression such as novels. Ludologists believe in studying "games as games," focusing on the rules, game world, and gameplay; they emphasize the importance of game design in both the formal composition and the transmission of meaning. For instance, in an analysis of *The Sims*, Pérez-Latorre (2010) suggests the use of rewards such as virtual money in game design can communicate implicit meanings such as consumerism and capitalism values. A representative work in this field is *Half-Real: Video Games Between Real Rules and Fictional Worlds* (Juul, 2005), which examines how rules provide challenges, learning, and enjoyment for players and how a game cues the player into imagining its fictional world.

The theoretical perspective of our research supports an intersection between narratology and ludology, a positioning shared by other authors such as Pérez-Latorre (2010) and his "Social Discourse of Video Games Analysis Model," which also integrates both perspectives for game analysis. We cannot treat video games only as a narrative form ignoring its peculiarities, but at the same time, the fact that video games are games by no means excludes them from having narrative qualities. Every video game has a message to transmit and a certain perspective on the world, on what is victory, and on how to achieve it. From narratology, we take into consideration techniques such as observing the role of the player in its environment or the story lines with the unfolding of plots and, from ludology, the analysis of micro structures in relation to the overall design, the game dynamics, and mechanics.

In the second category, authors like Gee (2004) o Prensky (2001) propose the "digital game-based learning" model, based on the use of online games as tools to support teaching and learning, offering docents and students a different educative experience that can be applied to subjects like science. Gee (2008) argues that well-designed online games can offer the possibility to be implemented in educational contexts because they can contribute to content development and foster skills and abilities, having positive outcomes on students´ knowledge. Other authors have examined possible effects of playing video games with pro-social content and found out an increase of positive emotions, attitudes and behaviors (Greitemeyer, 2011; Reeves et al., 2015; Yang et al. (2016). Yet, scholars like Soekarjo & van Oostendorp (2015) suggest that limited empirical evidence is currently available to prove the effectiveness of games

in attitude or behavior change. The Theory of Planned Behavior (Ajzen, 2002) has been used to explain the relationship between playing games, self-efficacy, and behavioral intentions or actual behavior change. Concretely, the theory postulates that a positive attitude towards a particular behavior in combination with positive subjective norms and a higher degree of perceived control will likely positively influence a person's intention to perform that behavior, and increase the likelihood that the behavior will be performed.

On the other side of the spectrum, previous research has focused on studying negative effects of playing games, especially violent games. Meta-analytic evidence has shown that playing violent video games is associated with an increase in aggression and anti-social behavior (Anderson et al., 2010). Greitemeyer et al. (2012), however, suggest that playing a team-player video game in which players work together as teammates reduces the negative effects of games. Therefore, depending on the content and design of the game, the context that involves players, and the playing amount, neither positive nor negative effects of video game exposure could be expected (Gentile, 2011).

➔ Research methods

Next we summarize the research methods used to achieve each of the objectives of this thesis:

Objective 1: To develop and propose a set of validated criteria

To achieve the first objective, we use the **Delphi method**, a structured and interactive process to collect opinions that establish consensus, based on the experiences and judgments of experts (Scapolo & Miles, 2006). This method is usually chosen among others methods when we are dealing with a novel field with not enough data to interpret the study object and there is a need to clarify analysis categories or criteria. Another reason is that the Delphi method aims at maximizing the advantages of methods based on expert groups and reduces its disadvantages by deleting negative interactions with the goal of achieving agreement among experts (Linstone & Turoff, 1975).

First of all, we designed a protocol, in which we stated the objective, established the characteristics and profiles of the experts, identified a first list of dimensions and criteria, and set up a calendar, communication strategy and validation process. In our case, a total of thirteen experts from Spain and abroad participated in the study. The experts were chosen for their theoretical and practical knowledge, motivation to participate in the study and feasibility of contact; their areas of expertise are communication, education, games and climate change. The technique consisted in three consulting rounds (Figure 2). Experts emitted their opinions and were able to reconsider their position when getting feedback about the results from the other experts. Consensus was taken into consideration as a guiding principle during the entire process; therefore, once consensus and stability of results were achieved the process was concluded. Article 1 explains this process in great detail.

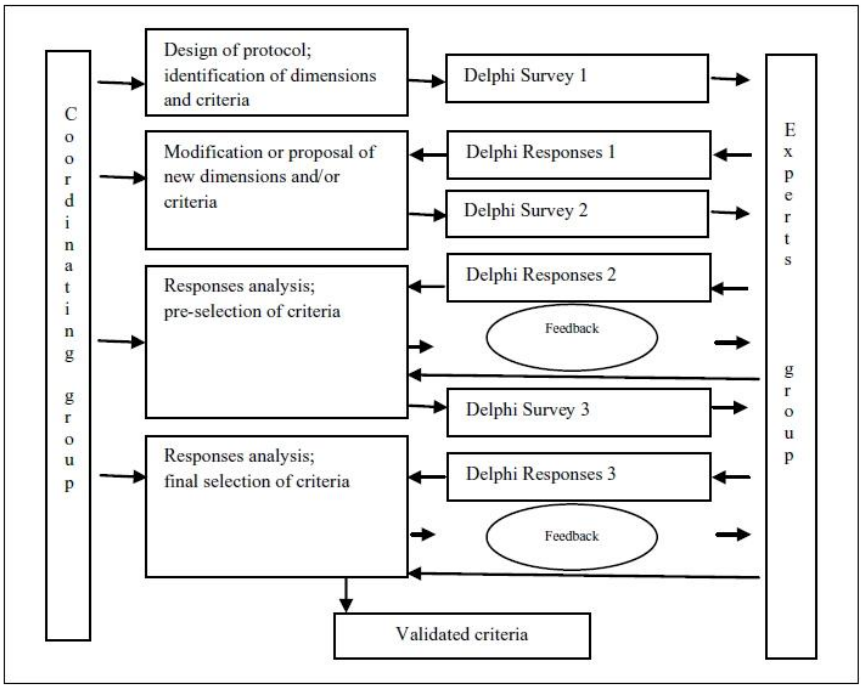


Figure 2: Delphi process in our study. *Source*. Adaptation from Pozo-Llorente et al. (2007)

Objective 2: to analyze communicative and educative features of online climate change games

In order to identify our sample of online climate change games - (a) produced in Spain; (b) produced in Spanish language-, a **web search** was carried out in the period May to July 2015 through the main search engines, using the following search request: ("video game" OR "online game" OR "educational game" OR "eco-game") AND ("climate change" OR "global warming" OR "sustainability" or "environment") in Spanish.

In order to select the games, there was a pre-selection stage and a final selection stage, where researchers interacted with the games to confirm that the required **selection criteria** were present: that they are hosted on a Web platform, played over the Internet (our study focuses on online games); that they are free of charge (which increases the possibilities that they will be used and accessed by teachers and teenagers with lower economical resources for these purposes); that they have communicative and educational objectives and a focus on climate change–related issues; that they seem aimed at an adolescent audience of 12+ (the target group of this study). Selected games were also recommended by institutions such as the National Center for Environmental Education, blogs from docents and educators, games platforms, and online gaming communities. Games that were excluded from the study were therefore commercial games, those that are only available through a software download or mobile applications, those whose website links were broken or not available by the time this research was initiated, and those aimed at children or primary education.

To analyze the games, researchers followed the list of validated criteria (vetted through the Delphi) and apply three different but complementary approaches: **narratology, ludology and qualitative content analysis**. From a narratological perspective, we observed the relevance of narrative and existence of narrators, the story lines with the

unfolding of plots, character depiction, the role of the player in its environment, and the spatial and temporal. From a ludological point of view, we focused on the analysis of microstructures in relation to the overall design, describing game dynamics and mechanics, the feedback system, use of rewards, and other important features.

In addition, the qualitative content analysis was used for those Delphi criteria that could be quantified. Qualitative content analysis focuses on manifest and latent features - unobserved concepts that cannot be measured directly but can be represented (Merkl-Davies & Koller, 2012)- and it entails quantification by coding frequencies to detect patterns in the data, in our case, preferred techniques among game producers and trends in online climate change game development. Levels, missions, or episodes were used as analysis units, and coding followed a deductive approach. In qualitative content analysis, intercoder reliability shows to what extent different coders agree on the coding of the same material (Neuendorf, 2002). In our study, this is achieve by the participation of two researchers in the coding and analysis of games, marking their responses and observations in different files, which later where combined into a single one after discussions. Despite the subjectivity of some of the criteria and the interpretative implications, both researchers agreed on all game features and there was no need to solve discrepancies.

Articles 4 and 5 follow this methodological approach, while articles 2 and 3 skip the quantification.

Objective 3: to examine the impact of a game on students´ awareness, knowledge, and attitudes.

To achieve this objective, we employ a **pretest-posttest design** research with an experimental condition (playing) and a control condition (not playing) in which students´ awareness, knowledge and attitudes regarding climate change and energy-related topics are assessed. The game used for the intervention is *2020 Energy,* a serious game targeting youth over twelve years-old that offers through nine missions questioning on the issues of efficiency and the reduction of energy consumption, renewable energies and sustainable development in the context of climate change. It is available in 10 languages and supported by the European Commission; from a suggested list of games by the researchers, the docents chose this game for the intervention.

- Sample: a total of 108 students participated in this study, 58 students from Spain (24 males and 34 females) and 50 students from the United States (21 males, 28 females and 1 unknown gender) between the ages of twelve and fourteen. Both samples correspond to four different core groups in middle schools. All students belong to middle-high classes and urban areas, and their teachers have previously addressed climate change very superficially in their science class.

- Instrument: an online pretest as well as an online posttest questionnaire, both with 17 questions which included open questions, multiple choice questions and rating scales to assess awareness, knowledge and attitudes. Questions and statements were compiled from similar previous studies and were based on topics present in the game, so item wordings and response scales resemble these

studies. The questionnaires were pretested in both countries for simple language and rephrased if necessary.

- Procedures: first of all, for the middle school classes in both countries, permission for the intervention to the board of directors and parents was applied for and accepted. In each school, one teacher worked hand-in-hand with the researchers from the beginning until the end of the intervention. The teacher was responsible for choosing two different groups for the intervention. The game session and the questionnaires were planned as activities during class hours by their correspondent teachers. The following schedule was followed:

GROUP 1: (2 weeks in advance) pre-test → GAMEPLAY → post-test
GROUP 2: (2 weeks in advance) pre-test → NO GAMEPLAY →post-test

- Data analysis: the researchers used Google Forms to compose and send the surveys online. The data was later transferred to the software SPSS Statistics in order to conduct descriptive statistics (frequencies, percentages) and inferential analyzes (chi-squared test). We translated the students´ names into numbers to guarantee their anonymity.

We complement this method with **observations** –researchers took notes of a) their face expressions; c) the chatting with their partner; and c) the questions and doubts they raised-, and **group discussions**: after finalizing the game, students participated in a discussion of around 10 min. guided by the researchers with the support of their teachers, aiming to be a collective exchange of ideas to share their opinions about the game (e.g. interesting, fun, boring, etc.), the missions they enjoyed the most, their main take-away, and their predisposition to adjust their life-styles.

Article 6 explains these methods in more detail.

To sum up, the methodological approach in this thesis can be observed in this table (Table 1):

Goals	Objectives	Sample	Data collection instruments and information processing
Analysis of the communicative and educative nature of games (Design, formal dimension, and significance studies)	develop and propose a set of validated criteria	panel of 13 experts	delphi questionnaires software SPSS Statistics
	analyze online climate change games	15 games produced in Spain 24 games produced in Spanish	web search; narratology, ludology and qualitative content analysis software SPSS Statistics
Analysis of the effects of games (Sociocultural dimension and video game reception studies)	examine the impact of a game on students´ awareness, knowledge, and attitudes	108 students (58 Spanish, 50 Americans)	pre-test / post-test; observation and group discussion software SPSS Statistics

Table 1: Summary of methodological approach

REFERENCES

Aguaded-Gómez, I. (2011). Children and young people: the new interactive generations. *Comunicar*, *36*(XVIII), 7-8. doi:10.3916/C36-2011-01-01

Ajzen, I. (2002). Perceived control, self-efficacy, locus of control, and the theory of planned behavior. *Journal of Applied Social Psychology*, *32*, 107-122. doi:10.1111/j.1559-1816.2002.tb00236.x

Anderson, C. A., Shibuya, A., Ihori, N., Swing, E. L., Bushman, B. J., & Sakamoto, A. (2010). Violent video game effects on aggression, empathy, and prosocial behavior in Eastern and Western countries. *Psychological Bulletin, 136*, 151–173.

Aparici R (2010). *Educomunicación: más allá del 2.0.* Bogota: Gedisa.

Aparici, R., & Silva, M. (2012). Pedagogy of Interactivity. *Comunicar*, *38*(XIX), 51-58. doi:10.3916/C38-2012-02-05

Bello-Benavides, L.O., Alatorre-Frenk, G. & González-Gaudiano, E. (2017). La educación ambiental en el Bachillerato Tecnológico. Un análisis crítico. Revista Interamericana de Educación de Adultos, 112-129.

Bofferding, L., & Kloser, M. (2015). Middle and high school students' conceptions of climate change mitigation and adaptation strategies. *Environmental Education Research*, *21*, 275-294. doi:10.1080/13504622.2014.888401

Chaparro-Escudero, M. (2013). Construcción de un imaginario perverso. La comunicación del desarrollo. *Telos, 94*, 31-42.

Cooper, C. B. (2011). Media literacy as a key strategy towards improving public acceptance of climate change science. *BioScience*, *61*, 231-237. doi:10.1525/bio.2011.61.3.8 PubMed

DEV. (2015). Libro blanco del desarrollo español de videojuegos (The white book of the development of Spanish video games). Madrid, Spain: Author.

Díaz-Nosty, B. (2013). Aproximación a la construcción interdisciplinar y de un nuevo paradigm: Comunicación, cambio climático y crisis sistemática. *Razón y Palabra*, *84*, 99-119. doi:10.4185/RLCS-64-2009-808-99-119

Egenfeldt-Nielsen, S., Smith, J. H., & Pajares-Tosca, S. (2008). *Understanding videogames*. New York, NY: Routledge.

Fielding, K., & Head, B. W. (2012). Determinants of young Australians' environmental actions: The role of responsibility attributions, locus of control, knowledge and attitudes. *Environmental Education Research*, *18*, 171-186. doi:10.1080/13504622.2011.592936

Frasca, G. (2007). *Play the message: Play, game and video game rhetoric* (Unpublished doctoral dissertation). IT University of Copenhagen, Copenhagen, Denmark. Retrieved from http://www.powerfulrobot.com/Frasca_Play_the_Message_PhD.Pdf

Gee, J. P. (2004). *Lo que nos enseñan los videojuegos sobre el aprendizaje y el alfabetismo*. Archidona, Spain: Aljibe.

Gee, J.P. (2008). Being a lion and being a soldier: learning and games. In J. Coiro, M. Knobel, C. Lankshear, y D. J. Leu (Eds.), *Handbook of Research on New Literacies* (pp. 1023-1036). New York: Routledge.

Gentile, D.A. (2011). The multiple dimensions of video game effects. *Child Development Perspectives, 5*, 75–81.

González-Gaudiano, E. (2007). Educación y cambio climático: un desafío inexorable. *Trayectorias, 25*, 33-44.

González-Gaudiano, E. (2012). Educación y cambio climático: aportes de las representaciones sociales. *Revista Contemporânea de Educação*, 7(14), 369-397.

González-Gaudiano, E. & Meira-Cartea, P.A. (2009). Educación, comunicación y cambio climático. *Trayectorias, 11*(29), 6-38.

Greitemeyer, T. (2011). Effects of prosocial media on social behavior: When and why does media exposure affect helping and aggression. *Current Directions in Psychological Science, 20*, 251–255.

Greitemeyer, T., Traut-Mattausch, E. & Osswald, S. (2012). How to ameliorate negative effects of violent video games on cooperation: Play it cooperatively in a team. Computers in Human Behavior, 28, 1465-1470.

Heras-Hernández, F., Meira-Cartea, P.A. & Benayas, J. (2016). Un silencio ensordecedor. El declive del cambio climático como tema comunicativo en España 2008-2012. *Redes.com. Revista de Estudios para el Desarrollo Social de la Comunicación*, *13,* pp. 31-54.

Juul, J. (2005). *Half-real: Video games between real rules and fictional worlds*. Cambridge: MIT Press.

Katsaliaki, K., & Mustafee, N. (2014). Edutainment for sustainable development: A survey of games in the field. *Simulation & Gaming*. Advance online publication. doi:10.1177/1046878114552166

Klein, N. (2015).This changes everything: capitalism vs. the climate. New York: Simon & Schuster Paperbacks.

León, B. (Coord.). (2014). *El periodismo ante el cambio climático: Nuevas perspectivas y retos*. Barcelona, Spain: Editorial UOC.

Liarakou, G., Sakka, E., Gavrilakis, C., & Tsolakidis, C. (2012). Evaluation of serious games, as a tool for education for sustainable development. *EURODL*, *15*(2), 96-110

Linstone, H. A., & Turoff, M. (1975). Introduction. In H. A. Linstone, & y M. Turoff (Eds.), *The Delphi method: Techniques and applications* (pp. 3-12). Reading, MA: Addison-Wesley.

Liu, S., & Ding, W. (2009). An approach to evaluation component design in building serious games. In M. Chang, R. Kuo, G.-D. Chen, & M. Hiroshe (Eds.), *Edutainment '09 Proceedings of 4th International Conference on E-learning and Games: Learning by playing* (pp. 141-148). Berlin, Germany: Springer.

Martínez-Valderrama, J., Ibáñez, J., Del Barrio, G., Sanjuán, M. E., Alcalá, F. J., Martínez-Vicente, S., & Puidgefábregas, J. (2016). Present and future of desertification in Spain: Implementation of a surveillance system to prevent land degradation. *Science of the Total Environment*, *563-564*, 169-178. doi:10.1016/j.scitotenv.2016.04.065

Martí-Parreño, J., Méndez-Ibáñez, E., Giménez-Fita, E., & Queiro-Ameijeiras, C. (2015). El uso de la gamificación en la educación superior: Propuesta de una ficha de análisis ludológico-narratológico. In M. A Ruiz Rosillo (Ed.), *XII Jornadas Internacionales de Innovación Universitaria*. Educar para transformar: Aprendizaje experiencial (pp. 103-111). Madrid, Spain: Universidad Europea de Madrid.

McGonigal, J. (2011). R*eality Is Broken: Why Games Make Us Better and How They Can Change the World*. London: Penguin.

Meira-Cartea, P.A. (2008). *Comunicar el cambio climático. Escenario social y líneas de actuación.* Madrid: Ministerio de Medio Ambiente y Medio Rural y Marino-Organismo Autónomo de Parques Nacionales.

Meira-Cartea, P.A. (2011). *La sociedad ante el cambio climático. Conocimiento, valoraciones y comportamientos en la sociedad española*. Madrid: Fundación Mapfre.

Mendler de Suarez J., Suarez, P., & Bachofen, C. (2012). *Games for a new climate: Experiencing the complexity of future risks*. Boston, MA: Boston University, The Frederick S. Pardee Center for the Study of the Longer-Range Future.

Merkl-Davies, D. M., & Koller, V. (2012). "Metaphoring" people out of this world: A critical discourse analysis of a chairman's statement of a UK defense firms. *Accounting Forum*, *36*, 178-193.

Mitgutsch, K., & Alvarado, N. (2012). Purposeful by design? A serious game design assessment framework. In *Proceedings of the International Conference on the Foundations of Digital Games* (pp. 121-128). New York, NY: ACM.

Moser, S. C. (2010). Communicating climate change: History, challenges, process and future directions. *WIREs Climate Change*, *1*, 31-53. doi:10.1002/wcc.011

Moser, S. C., & Dilling, L. (2011). Communicating climate change: Closing the science-action gap. In J. S. Dryzek, R. B. Norgaard, & D. Schlosberg (Eds.), *Oxford Handbook of climate change and society* (pp. 161-174). Oxford, England: Oxford University Press.

Murray, J. (1999). *Hamlet on the Holodeck*. Cambridge: MIT Press.

Neuendorf, K. (2002). *The content analysis guidebook*. Thousand Oaks, CA: Sage.

Nisbet, M., & Scheufele, D. (2009). What's next for science communication? Promising directions and lingering distractions. *American Journal of Botany*, *96*, 1767-1778. doi:10.3732/ajb.0900041

Partridge, E. (2008). From ambivalence to activism: Young people's environmental views and actions. *Youth Studies Australia*, *2*, 18-25.

Pérez-Latorre, O. (2010). *Análisis de la significación del videojuego: Fundamentos teóricos del juego, el mundo narrativo y la enunciación interactiva como perspectivas de estudio del discurso* (Unpublished doctoral dissertation). Barcelona, Spain: Universitat Pompeu Fabra, Departament de Comunicació.

Pozo-Llorente, M. T., Gutiérrez-Pérez, J., & Rodríguez-Sabiote, C. (2007). El uso del método Delphi en la definición de los criterios para una formación de calidad en animación sociocultural y tiempo libre. *Revista de Investigación Educativa*, *25*, 351-366.

Prensky, M. (2001). Digital natives, digital immigrants. *On the Horizon*, *9*(5), 1-6. doi:10.1108/10748120110424816

Reckien, D., & Eisenack, K. (2013). Climate change gaming on board and screen: A review. *Simulation & Gaming*, *44*, 253-271. doi:10.1177/1046878113480867Reeves et al., 2015

Salen, K., & Zimmerman, E. (2004). *Rules of play: Game design fundamentals*. Cambridge: MIT Press.

Scapolo, F., & Miles, I. (2006). Eliciting expert's knowledge: A comparison of two methods. *Technological Forecasting & Social Change*, *73*, 670-704.

Soekarjo M., & van Oostendorp H. (2019). Measuring Effectiveness of Persuasive Games Using an Informative Control Condition. *International Journal of Serious Games*, 2(2), 6-20.

Tejeiro, R., & Pelegrina, M. (2003). *Los videojuegos: Qué son y cómo nos afectan*. Barcelona, Spain: Ariel.

Wu, J., & Lee, J. (2015). Climate change games as tools for educational and engagement. *Nature Climate Change*, *5*, 413-418. doi:10.1038/NCLIMATE2566

Yang, J.C., Lin, Y.L., & Liu, Y.C (2016). Effects of locus of control on behavioral intention and learning performance of energy knowledge in game-based learning. *Environmental Education Research*, 1-14. doi:10.1080/13504622.2016.1214865

PART II

PUBLICATIONS & RESULTS

CHAPTER 4: ANALYSIS OF THE COMMUNICATIVE AND EDUCATIVE NATURE OF GAMES

Despite discussions have begun on the analysis of serious games in general, and on the analysis of sustainability and climate change games in particular, previous research in this field mostly focuses on general characteristics that can help identify the game without further going into details. In order to evaluate the educommunicative potential of these games, it is necessary to look at both educative and communicative features, integrating a narratological (understands the game as a medium to generate stories and transmit contents) and a ludological view (pays attention to the meanings hidden behind the design).

Article 1 describes the process of developing a set of analysis criteria which reach the consensus of an international panel of 13 experts in the fields of videogames, communication and education, by making use of the Delphi method: a structured and interactive process to collect opinions that reach an agreement, based on the experiences and judgments of experts. This method is usually chosen among others methods when we are dealing with a novel field with not enough data and there is a need to clarify analysis categories or criteria. To our knowledge, this is the first time that the Delphi method is used to develop a set of criteria in the field of online climate change games. The article explains in detail the three consulting rounds which were needed to agree on a final set of 51 analysis criteria divided into these five dimensions:

- Identification: features that help identify and locate the game
- Narrative: analysis of the narrative and fictional context elements
- Contents: analysis of the information and messages transmitted about climate change
- Gameplay: analysis of the game design and formal structures
- Didactics: analysis of the pedagogical elements

From this process, we highlight the high degree of representativeness of the experts and the high consensus reached in the selection of criteria. In the first round, we shared with the experts a list with the first group of dimensions/criteria, and opinions were quite favorable; in the second stage, the criteria that got a consensus of 90% (high + medium) were selected, a robust value for the selection process leaving 10% margin for discrepancies; and in the third stage, the criteria that did not pass the second phase were assessed once more in order to reach consensus on the final set. Once stability of results was achieved and experts agreed on the final set, the process was concluded. Finally, this article also provides a description of each of the criteria and recommendations on how to put them into practice whether by using the complete set or part of it.

Article 1 inspires and serves as a framework for the development of articles 2, 3, 4 and 5, which illustrate the use of the criteria and demonstrate their usefulness in examining trends and preferred communicative and educative techniques within online climate change games.

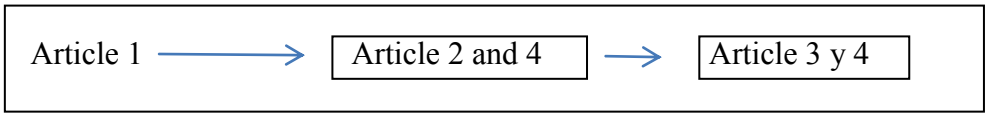


Figure 2. Relationship between articles

Particularly, articles 2 and 3 contribute to a preliminary approach to online climate change games, focusing on a sample of 5 games produced in Spain: 1. Actúa con tu consumo / *Act on your consumption;* 2. Alerta CO2 / *CO2 Alert;* 3. Climántica; 4. Misión posible, salvar el planeta / *Mission possible, save the planet;* 5. My Green Energy Planet. These games appear as the top results during web searching, in the main blogs specialized in environmental education and as recommended material by governmental and non-governmental institutions. They are also mentioned among users in online videogame communities. Because we pay attention to a small sample, these articles present a qualitative analysis of these games using the Delphi criteria as indicators: article 2 is centered on evaluating the communicative features -Delphi criteria under the dimensions of narrative, contents, and gameplay-; and article 3 (written in Spanish) expands the evaluation to both communicative and educative features- Delphi criteria under the dimensions of narrative, contents, gameplay and didactics-, presenting the digital game-based learning model as a theoretical framework and targeting readers in the field of science education.

Article 4 goes one step further and expands the sample to 15 games. These games represent all the online climate change games produced in Spain which responded to our selection criteria: hosted on a Web platform, free of charge, and targeting a young audience of over 12 years old. This article focuses exclusively on analyzing communicative features, since it is intended for readers in the field of science communication, applying content analysis, narratology, and ludology techniques. Lastly, in article 5 we examine the highest number of games with a sample of 24 online climate change games available in Spanish language, independently of whether the production is from Spain or another country. In this case, we analyze both communicative and educative features, and as in the previous case, we also apply content analysis, narratology, and ludology techniques following each of the Delphi criteria. Interestingly enough, article 5 reveals similar results as article 4 despite the fact that the sample is expanded to games that are not necessarily produced in the Iberian Peninsula.

This figure (Figure 3) shows the scope of the different publications presented in this chapter. It also represents how the five dimensions approved through the Delphi process combine an educative and a communicative perspective to analyze online climate change games, integrating a narratologial and ludological view.

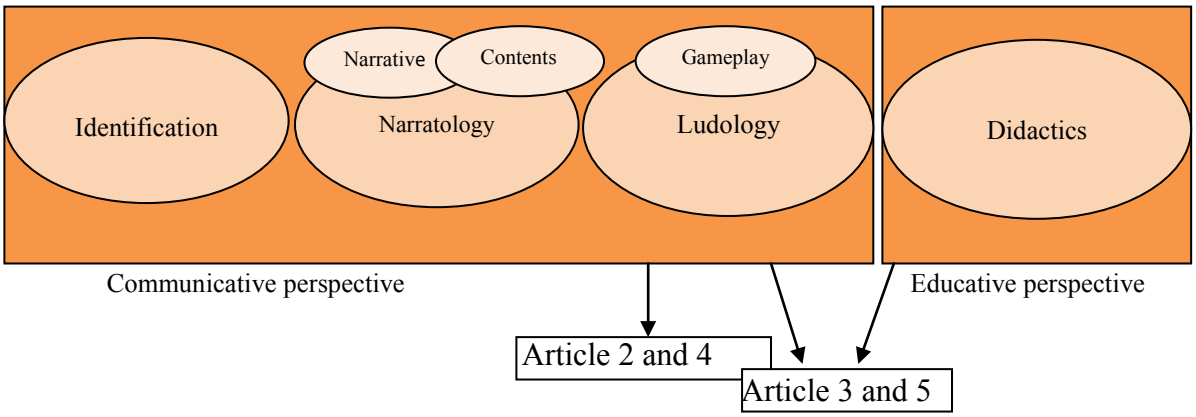


Figure 4. Dimensions for analysis and publications´ focus

In summary, the most relevant findings from these analyses are:

- Identification: the majority of games are located in a section from the producer´s website, do not have an app for mobile phones and do not translate the games in different languages. NGOs are the main producers, followed by the private sector, which in some cases coincides with electrical companies with a bad reputation when it comes to pollution. Most of the games aim at providing some basic knowledge on climate change and related issues, developing familiarity with the topic, followed by promoting a change in attitudes or behaviors.
- Narrative: there is a general preference toward portraying an ordinary citizen and focusing on local scenarios, in which players must make decisions at home, within their communities or in territories they have to manage to reduce carbon emissions. Most games allow players to make decisions in the present and then travel into the future, where they can see the consequences of their choices.
- Contents: the term climate change is preferred over global warming, and this is mostly portrayed from a mitigation perspective with topics such as energy conservation. Another trend is to explicitly define certain scientific concepts related to this phenomenon, and sometimes related to other environmental problems, mostly through a glossary of terms. Contextual information with references to climate change causes related to human activities and consequences is provided, and messages tend to provide a positive tone, focusing on solutions and empowerment to take action. However, despite there are some good examples, a greater degree of critical perspectives on the issue are missing, by for instance framing messages in terms of justice, solidarity, mobilization, or alternative economic models that go beyond "green" capitalism and technological progress.
- Gameplay: the majority of games are characterized as having a medium-high degree of interactivity. When looking at the game dynamics, challenge, progression, discovery and ability are the most common; most games encourage individual skills development, so a greater integration of comradeship dynamics and cooperation mechanisms in their structure and design is missing. Results also show that most of the games use an intangible reward system to reward individual actions, such as extra points, unblocking levels or virtual coins by answering a quiz question correctly, making sustainable decisions under time pressure or doing well in the skill games.
- Didactics: most of the games are characterized by having different learning curves, mostly medium-low, facilitating the development of the majority of competences and abilities assigned by LOMCE (2015). The interdisciplinarity of their contents facilitate their use for different courses; they also offer possibility of group work by sharing computers when playing; and the possibility of evaluation by docents. However, the majority does not include didactic guidelines to help teachers implementing the game at class and few are available for students with functional disability.

4.1. Criterios de evaluación de juegos en línea sobre cambio climático: aplicación del método Delphi para su identificación

Article 1: Ouariachi, T., Gutiérrez-Pérez, J., y Olvera-Lobo, M.D. (2017) "Criterios de evaluación de juegos en línea sobre cambio climático: aplicación del método Delphi para su identificación". *Revista Mexicana Investigación Educativa, 22* (73) (en prensa).

El fenómeno de la gamificación en los procesos de enseñanza-aprendizaje sobre cambio climático a través de juegos en línea es una tendencia en alza. Los juegos en línea sobre cambio climático se perfilan como herramientas prometedoras ya que permiten exponer a los jóvenes a los problemas y decisiones que van a encarar en el futuro de forma directa. A pesar del creciente interés, los docentes son escasamente orientados acerca de las características de los juegos disponibles en la red y su potencial educomunicativo. El objetivo fundamental de este trabajo es ofrecer un instrumento validado de evaluación para los juegos en línea sobre cambio climático, compuesto por criterios consensuados a partir del juicio de expertos mediante el método Delphi. Esta herramienta cuenta con cinco dimensiones de evaluación: identificación, narrativa, contenidos, jugabilidad y didáctica.

4.1.1. Introducción

El *cambio climático* es uno de los principales problemas al que se enfrenta la humanidad, una amenaza de carácter ambiental, social, económico, ético y político que por sus dimensiones globales requiere de una nueva forma de acción ciudadana para la que las nuevas generaciones están llamadas a actuar. Sin embargo, tal y como revelan las últimas encuestas sobre percepción del cambio climático en España y en Europa, el conocimiento del problema es aún limitado y se observa una notable ausencia de compromiso para adoptar medidas de mitigación y de adaptación al cambio climático (Bofferding y Kloser, 2014

Diversos estudios han revelado que la manera en la que se ha comunicado el cambio climático hasta ahora no ha sido efectiva y que, por lo tanto, existe una necesidad urgente de buscar nuevas estrategias para fomentar la concienciación y la acción social (Cooper, 2011; Díaz-Nosty, 2013; Gónzalez-Gaudiano y Meira-Cartea, 2009; Meira-Cartea, 2008; Moser, 2010; Moser y Dilling, 2011; Reckien y Eisenack, 2013). De la misma manera, los programas educativos convencionales deben afrontar desafíos importantes para adaptarse a los nuevos estilos de procesamiento de información y motivaciones de los jóvenes, razón por la cual las instituciones educativas buscan la manera de modernizar sus métodos de transmisión del conocimiento (Aparici y Silva, 2012). Tomando a los jóvenes como sector poblacional objetivo, sería lógico proponer estrategias educativas que se correspondan con el nuevo paradigma comunicativo de las llamadas "generaciones interactivas" (Aguaded-Gómez, 2011) o "nativos digitales" (Prensky, 2001), quienes han crecido en un mundo rodeado de ordenadores, Internet o videojuegos.

El cambio en la forma de interactuar requiere revisar los paradigmas educativos existentes y caminar hacia nuevos formatos educomunicativos que faciliten una interacción natural entre persona, interfaz y entorno. Los videojuegos en general, y los juegos en línea en particular, ofrecen esa posibilidad inagotable de alfabetización científica y ambiental de las nuevas generaciones de jóvenes. Gracias a la interactividad

y a su capacidad de inmersión, estas herramientas ofrecen oportunidades para exponer a los jóvenes a los problemas y decisiones que van a encarar en el futuro y experimentarlos de forma directa, por lo general, adoptando roles de personajes que han de ser capaces de tomar decisiones sostenibles. Videojuegos bien diseñados pueden promover competencias y habilidades, contribuir a aportar contenidos al currículo y generar experiencias que no serían posibles en la vida real (Gee, 2004). Corresponde a la investigación sistemática mostrar su potencial, establecer tipologías y evaluar su calidad en función de diferentes criterios de uso.

Según un estudio llevado cabo en la Unión Europea, existe un gran potencial en la aplicación de juegos en línea para la enseñanza-aprendizaje y un fuerte interés entre la comunidad educativa en la introducción de enfoques innovadores basados en los juegos; sin embargo, la accesibilidad universal de la Web hace que cada día se multiplique la cantidad de recursos, lo cual no implica que todos ellos sean adecuados para los objetivos docentes (European SchoolNet, 2009). Entre otros aspectos, este estudio resalta que los docentes son escasamente orientados acerca de cuáles son los aspectos y características más relevantes de los juegos disponibles en la red y qué juegos se adaptan a sus necesidades, además, aún cuentan con escasas herramientas de evaluación de los mismos. El presente trabajo aborda estas cuestiones y pretende contribuir a apoyar a la comunidad educativa y a la sociedad en la toma de decisiones ofreciendo un instrumento de evaluación que les ayude a la selección de juegos en línea sobre cambio climático, mediante el conocimiento de sus características y la valoración de su potencial educomunicativo.

El objetivo fundamental de este trabajo se orienta a definir unos criterios consensuados de evaluación de juegos en línea centrados en contenidos sobre cambio climático, a partir del juicio aportado por un grupo de expertos, de cara al diseño de un instrumento validado de evaluación sobre juegos de este tipo. A continuación, presentamos una definición de nuestro objeto de estudio, un marco para la fundamentación teórica del problema objeto de estudio y el proceso metodológico seguido para definir unos criterios consensuados mediante el método Delphi. Como resultado de este proceso se han obtenido un conjunto de criterios, validados empíricamente, que permiten evaluar, desde una perspectiva educomunicativa, la calidad de los juegos en línea sobre cambio climático.

4.1.2. Una aproximación al concepto de juegos en línea sobre cambio climático

A diferencia de la televisión o del cine, donde el espectador es simplemente un consumidor pasivo de información, en los juegos el usuario experimenta por sí mismo, resuelve problemas y situaciones de naturaleza compleja, interactúa con distintos tipos de variables y desempeña diferentes roles a través de personajes o avatares, desde perspectivas que, de otro modo, sería imposible llevar a cabo en la vida real. Pero ¿qué se entiende por videojuego, y por juego en línea? ¿Qué caracteriza a los juegos sobre cambio climático?

Los videojuegos han sido definidos como juegos electrónicos que se sirven de la tecnología informática y permiten la interacción en tiempo real del jugador con la máquina, y en el que la acción se desarrolla sobre un soporte visual (Tejeiro-Salguero y Pelegrina del Río, 2003). En este trabajo, utilizaremos los términos videojuego y juego

en línea indistintamente si bien, éste último constituye una modalidad de videojuego que cuenta con la particularidad de que se accede a través de un navegador web y está disponible en Internet.

A pesar de que algunos autores no incluyen a los videojuegos educativos (finalidad aprendizaje-enseñanza) dentro de los videojuegos (finalidad lúdica), en este trabajo se considera que en los videojuegos educativos el componente lúdico cada vez es mayor por lo que deben considerarse como tales. El usuario de videojuegos pretende divertirse o entretenerse, pero al mismo tiempo está desarrollando capacidades y conocimientos, especialmente cuando la temática del juego es seria, como es el caso del cambio climático. A este tipo de videojuegos que van más allá de la diversión e incluye fines comunicativos y educativos se les ha denominado también "serious games" (Katsaliaki y Mustafee, 2014). Los llamados juegos del cambio climático, juegos del clima o juegos del calentamiento global pertenecerían a esta categoría (Reckien y Eisenack, 2013).

Por lo tanto, al referirnos a "juegos en línea sobre cambio climático" nos centramos en juegos con temática relacionada con el cambio climático, con fines comunicativos y científico-educativos, que integran la diversión y el entretenimiento, y que están disponibles en Internet. Estos juegos suelen plantearse objetivos comunicativos como: *a)* desarrollar familiaridad y conocimiento sobre el tema, *b)* concienciar sobre causas y consecuencias, *c)* despertar emociones y reflexiones científicas, *d)* estimular el desarrollo de ideas creativas y soluciones y *e)* fomentar el cambio de actitudes y comportamientos.

Existe una gran variedad de juegos en línea sobre cambio climático destinados a los jóvenes y son de acceso gratuito en Internet. Por ejemplo, EnerCities (disponible en 6 idiomas), EcoVille (en 13 idiomas), EfficienCity (en inglés), EnergyVille (en inglés), Clim'Way (en inglés y francés), BBC ClimateChallenge (en inglés), Eco-Agents (en 24 idiomas), o CEO2 ClimateGame (en inglés). La mayoría de estos juegos están disponibles en habla inglesa, pero también existe una gran variedad de juegos en idiomas como el español, es el caso de Climántica, Alerta CO2, Misión posible Salvar el Planeta, My Green Planet, o Actúa con tu Consumo.

A pesar del aumento de producción de este tipo de juegos, el desarrollo de proyectos como *Climate Reality* de Al Gore que impulsó el diseño de juegos creativos orientados a diseminar mensajes sobre cómo afrontar el cambio climático, o la creación de grupos de investigación como *Gaming the Future: Designing video games that change the way people think about climate change* lanzado en 2015 por la organización estadounidense *Science for Nature and People* (SNAP) *con la intención final de crear un centro destinado al diseño de este tipo de videojuegos, nos encontramos ante un campo de estudio relativamente reciente.*

4.1.3. Modelos de análisis de videojuegos

La Teoría del videojuego tardó unos 30 años en confirmarse desde que apareció *Pong*, el que se considera el primer videojuego de la historia. En 2011, Espen Aarseth de la *IT University of Copenhagen* fundó la primera revista académica para estudiar videojuegos, *Game Studies*, y desde entonces, distintos modelos para analizar y evaluar videojuegos han sido propuestos desde diversas disciplinas (qted. in Pérez-Latorre

2010: 130): la teoría del diseño de juegos y ludología (Juul, 2005); narratología del videojuego (Murray, 1999); semiótica y análisis discursivo del videojuego (Frasca, 2007); estudios culturales (Taylor, 2006); estudios de efectos psicosociales (Tejeiro-Salguero et al., 2009); y estudios sobre educación y serious games (Gee, 2004; Bogost, 2006).

El estudio que hemos realizado está inspirado en el "Modelo de análisis de la significación del videojuego" de Pérez-Latorre (2010). Desde esta perspectiva se integran una visión del juego narratologista, que entiende este medio como una forma de narrativa y de generar historias, así como una visión ludologista, que tiene en cuenta la retórica que oculta el diseño de las dinámicas, mecánicas y elementos del juego. A esto, se añade una visión pedagógica, con el fin de evaluar su potencial educativo de cara a su introducción en el aula. Así, conseguiremos diseñar un instrumento de evaluación integrador desde una perspectiva narratológica, ludológica y pedagógica, analizando elementos comunicativos y educativos. Aunque las discusiones sobre el análisis de videojuegos ya han comenzado y varios autores han propuesto criterios de análisis (Liarakou et al., 2012; Liu y Ding, 2009; Martí-Parreño et al., 2015), muchos de estos estudios se centran sólo en características comunicativas o sólo en características pedagógicas, olvidando la integración de las mismas.

4.1.4. Enfoque metodológico

En este estudio hacemos uso de un proceso de recogida de opiniones grupales, consensuadas y fidedignas mediante el método Delphi, un proceso sistemático, interactivo y colaborativo encaminado a la obtención de opiniones y consenso a partir de experiencias y juicios subjetivos de expertos (Scapolo y Miles, 2006; Pozo-Llorente, Gutiérrez-Pérez y Rodríguez-Sabiote, 2007). Se acude a esta técnica cuando se requiere una clarificación de los criterios de evaluación o categorías de análisis, al ser un campo novedoso y no existir datos suficientes a priori para perfilar la interpretación del objeto de estudio.

Con el método Delphi se pretende maximizar las ventajas que presentan los métodos basados en grupos de expertos y reducir sus inconvenientes, aprovechando la sinergia del debate en el grupo y eliminando interacciones negativas con el fin de alcanzar un consenso entre los expertos (Linston y Turoff, 1975). En cuanto al número óptimo de expertos en el proceso, estudios realizados por la *Rand Corporation* confirman que un panel de expertos formado como mínimo por siete expertos se considera válido. No obstante, y aunque el error disminuye por cada experto añadido, no resulta aconsejable recurrir a más de 30 expertos, pues el aumento en la previsión es muy pequeño (Astigarraga, 2008). En este trabajo, en el que se ha contado con 13 expertos, el proceso ha sido interactivo, los expertos han emitido su opinión y han podido reconsiderar sus posturas al conocer los resultados globales del grupo mediante un proceso de retroalimentación encadenado en varias fases de consulta. Se ha garantizado el anonimato de los participantes en todo momento para evitar influencias. Finalmente, se ha considerado la respuesta estadística del grupo como estrategia.

4.1.5. Proceso metodológico

El punto de partida que aquí se plantea es la existencia de un problema de investigación que requiere de un grupo de expertos cuyos conocimientos y experiencia se consideran de antemano apropiados y pertinentes para alcanzar el objetivo de este estudio. El grupo coordinador de la técnica –constituido por especialistas en comunicación, educación y ciencia– realiza la selección del grupo de expertos, asegurando la mayor participación posible en el estudio. Asimismo, diseña los cuestionarios en función de las respuestas que los expertos aportan en cada fase con el propósito de ir acercando respuestas y disminuir la dispersión y variabilidad de opiniones. En nuestro caso, tres ciclos de consulta a los expertos seleccionados fueron suficientes, empezando con una propuesta cualitativa abierta y concluyendo con un instrumento final más cerrado y pautado:

1) En primer lugar, se planteó una consulta abierta y espontánea no pautada a un grupo de expertos con perfiles profesionales diversos relacionados con el tema de estudio. Tras remitirles información contextual sobre la investigación que se pretendía realizar y la ficha de evaluación preliminar diseñada por el grupo coordinador a partir de una exhaustiva revisión bibliográfica, se les formularon las siguientes dos preguntas abiertas:

• Pregunta 1: ¿Qué ventajas puede tener el disponer de un instrumento validado de evaluación de juegos ecológicos centrados en contenidos sobre cambio climático?
• Pregunta 2: ¿Qué otros criterios de evaluación añadiría a esta ficha de evaluación preliminar?

Así, se consiguió abrir un debate sobre las oportunidades del objeto de estudio, reestructurar la ficha de evaluación e identificar nuevos criterios de evaluación.

2) En segundo lugar, se arbitró una valoración de los criterios de evaluación en términos ordinales (importancia alta, importancia media, importancia baja), a través de un cuestionario online, con el fin de calibrar discrepancias y conseguir un primer consenso en la primera selección de las variables de análisis. La selección de criterios en esta etapa se basó en la obtención de un consenso del 90% (porcentaje acumulado de importancia alta e importancia media).

3) Finalmente, se solicitó a los expertos un posicionamiento desde sus respectivas áreas de experiencia ante aquellos criterios que no superaron la segunda fase, con el fin de calibrar consenso y confirmar la selección final de criterios. Esta valoración se planteó a través de un cuestionario con preguntas cerradas dicotómicas, en la que los expertos debían responder si estaban de acuerdo o no en que los criterios con un consenso menor del 90% se quedaran fuera del instrumento de evaluación de juegos en línea sobre cambio climático.

Por tanto, el nivel de saturación lo estableció, por un lado, el consenso (grado de convergencia de las estimaciones individuales en un mínimo del 90%) y, por otro, la estabilidad (no variabilidad significativa de las opiniones de los expertos entre rondas sucesivas, independientemente del grado de convergencia).

El gráfico siguiente resume el proceso:

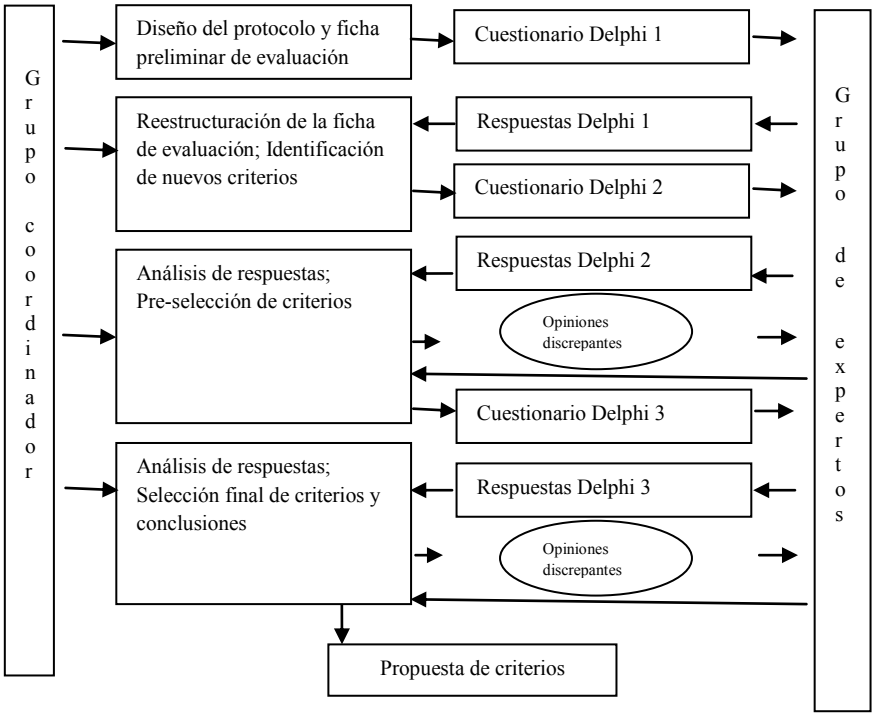


Grafico 1. El proceso Delphi (adaptado de Pozo-Llorente et al, 2007)

En este proceso se ha hecho uso de la aplicación *Google Drive*, una aplicación *open source* que permite de forma gratuita diseñar un cuestionario online, distribuirlo vía email y descargar los datos para su posterior análisis. Para el análisis de datos se ha hecho uso del programa estadístico *SPSS*.

Fase 1: diseño del protocolo

En esta fase se ha diseñado el protocolo de la técnica Delphi: definición del problema, definición de objetivos, identificación de variables o criterios, constitución del grupo coordinador, establecimiento de las características y perfiles de los expertos, establecimiento del calendario y la estrategia de participación con los expertos. La tabla 1 resume los descriptores básicos.

Definición del problema	La idoneidad de un instrumento de evaluación de juegos ecológicos en línea centrados en contenidos sobre cambio climático, validado por un grupo de expertos interdisciplinar e internacional, que permita a los docentes en particular, y a la sociedad en general, valorar el potencial educomunicativo de los juegos disponibles en la red sobre esta temática.
Definición de los objetivos	1) Consensuar unos criterios de evaluación de juegos ecológicos en línea centrados en contenidos sobre cambio climático. 2) Diseñar un instrumento validado de evaluación de juegos de este tipo.
Grupo coordinador	Grupo investigador responsable (Departamento de Información y Comunicación, y Departamento de Métodos de Investigación y Diagnóstico en Educación de la Universidad de Granada)
Determinación de las características de los expertos participantes	1) Criterios para su selección: - Conocimientos teóricos y/o prácticos sobre el tema. - Motivación para participar en esta dinámica. - Facilidad de contacto. - Perfiles profesionales diferenciados. 2) Área geográfica: distintas regiones españolas y otros países

Participantes invitados	Participantes invitados: 13 expertos de España y otros países Especialistas (detalles en Tabla 2) -Área de la Comunicación. -Área de la Gamificación. -Área de la Educación.
Calendario	Un Semestre: Tres rondas de recogida de información, una consulta cada dos meses. Informe final de cortesía tras la tercera consulta.
Vía de comunicación	Teléfono y/o correo electrónico.

Tabla 1. Protocolo de la técnica

La muestra participante (tabla 2) consta de un total de 13 expertos de 4 países y contextos culturales diferentes, pertenecientes a tres perfiles de especialidad distintos (comunicación, gamificación y educación).

	Cargo	**Procedencia**
Área de la Comunicación	Director del Centro de Comunicación para el Cambio Climático, profesor Universidad George Mason	Estados Unidos
	Profesora en Universidad Tecnológica de El Salvador, experta en cultura científico-tecnológica, comunicación social y género	El Salvador
	Profesora en la Universidad Autónoma de Barcelona; experta en educomunicación y comunicación audiovisual	España (Cataluña)
	Divulgadora científica y especialista en Web 2.0 y comunicación en Parque de las Ciencias de Andalucía	España (Andalucía)
Área de la Gamificación	Coordinadora del proyecto Gamestar(t), experta en innovación pedagógica a través de videojuegos	España (Madrid)
	Coordinador del programa Game On y experto serious games en Universidad Hanze	Países Bajos
	Profesor de Informática en la UGR, director del laboratorio de Investigación en Videojuegos y E-learning (LIVE)	España (Andalucía)
	Miembro de SNAP "Gaming the future of climate communications" y Critical Gaming Project en Univ. Washington	EstadosUnidos
Área de la Educación	Director del proyecto de educación ambiental Climántica y profesor de secundaria	España (Galicia)
	Doctora en TICs e innovación metodológica, profesora en educación secundaria.	España (Madrid)
	Gamificador y profesor en educación secundaria	España (Madrid)
	Antropólogo e investigador en educación y nuevas tecnologías en Universidad Tecnológica de El Salvador	El Salvador
	Coordinadora del proyecto transmedia Jóvenes contra el Cambio Climático, investigadora en la Universidad Complutense de Madrid y profesora de educación secundaria	España (Madrid)

Tabla 2. Tipos de participantes

Fase 2: fase de desarrollo

El instrumento empleado para la recogida de información es el cuestionario, ya sea con preguntas abiertas o cerradas. El primer cuestionario empleado para la recogida de información fue de naturaleza cualitativa y con preguntas abiertas para que los expertos pudieran compartir su opinión con respecto a una primera propuesta de instrumento de evaluación de juegos en línea sobre cambio climático.

Esta primera propuesta consistió en una ficha de evaluación preliminar, inspirada en el "Modelo de análisis de la significación del videojuego" de Pérez-Latorre (2010). A la visión comunicativa que caracteriza a este modelo, se añade una visión pedagógica, con el fin de evaluar su potencial educativo de cara a su introducción en el aula. La ficha de evaluación quedó dividida en 5 dimensiones, que sirven de guía para clasificar los

criterios de evaluación desde el prisma comunicativo y educativo: 1- Identificación (rasgos que ayudan a identificar y localizar el juego); 2- Enunciación (juego como proceso de diálogo); 3- Narratología (juego como narración); 4- Ludología (juego como juego); y 5- Didáctica (juego como recurso educativo).

Los criterios de evaluación (variables de análisis) son los elementos a analizar en cada uno de los juegos en línea. Estos criterios fueron determinados tras una exhaustiva revisión bibliográfica desde la perspectiva de su potencial para realizar un análisis de contenido y del discurso de los videojuegos como herramientas de comunicación, además de permitir valorar su capacidad pedagógica, como paso previo a su implementación en contextos educativos. La tabla 3 presenta cada una de las dimensiones con sus respectivos criterios de evaluación iniciales.

1. IDENTIFICACIÓN
• nombre del juego • URL • disponibilidad de aplicación para móviles • idioma (Reckien y Eisenack, 2013) • país de origen de la producción • género del juego (EuropeanSchoolNet, 2009; Lacasa 2011) • descripción/resumen
2. ENUNCIACIÓN
• nombre del productor/autor • tipo de productor/autor (Katsaliaki, 2014; Reckien y Eisenack, 2013) • público objetivo (Katsaliaki y Mustafee, 2014; Reckien y Eisenack, 2013) • finalidad comunicativa (Moser y Dilling, 2011) • marcas enunciativas (Pérez-Latorre, 2010)
3. NARRATOLOGÍA
• relevancia de la narrativa (Lacasa 2011; Pérez-Latorre, 2010) • existencia de un narrador (Lacasa 2011; Pérez-Latorre, 2010) • historia/trama global (Lacasa 2011; Pérez-Latorre, 2010) • historia/trama por episodios, niveles (Lacasa 2011; Pérez-Latorre, 2010) • representación del personaje/avatar (Lacasa 2011; Pérez-Latorre, 2010) • rol del personaje (Katsaliaki, 2014; Lacasa 2011; Pérez-Latorre, 2010) • representación del entorno (Lacasa 2011; Pérez-Latorre, 2010) • dimensión/espacio (Lacasa 2011; Pérez-Latorre, 2010; Meira-Cartea, 2008; Reckien y Eisenack, 2013) • dimensión/ tiempo (Lacasa 2011; Pérez-Latorre, 2010; Meira-Cartea, 2008; Reckien y Eisenack, 2013) • conceptos empleados: cambio climático vs. calentamiento global (León, 2013) • presencia de falsos conceptos-errores (Meira-Cartea, 2008) • uso explícito de conceptos científicos (León, 2013) • uso explícito de fuentes de información (León, 2013; Piñuel-Raigada et al., 2009) • convergencia con redes sociales • perspectiva sobre cambio climático: mitigación vs. adaptación (Moser y Dilling, 2011) • temática principal (León, 2013; Piñuel-Raigada et al., 2009) • promoción de acciones (León, 2013; Meira-Cartea, 2008; Piñuel-Raigada et al., 2009) • contextualización: causas (León, 2013; Piñuel-Raigada et al., 2009) • contextualización: consecuencias (León, 2013; Piñuel-Raigada et al., 2009) • tono del mensaje (León, 2013; Meira-Cartea, 2008; Moser y Dilling, 2011) • imágenes empleadas (León, 2013; Moser y Dilling, 2011)
4. LUDOLOGÍA
• nº jugadores (Katsaliaki y Mustafee, 2014) • uso: individual vs. colectivo (EuropeanSchoolNet, 2009) • tipo de jugador (Kim, 2012) • duración (EuropeanSchoolNet, 2009) • niveles • nivel de interactividad (Grifeau, 2010) • misión del juego/objetivos finales (Katsaliaki y Mustafee, 2014; Pérez-Latorre, 2010) • misión del juego/objetivos instrumentales (Pérez-Latorre, 2010) • dinámicas del juego (Werbach, 2012)

• mecanismos del juego (Pérez-Latorre, 2010; Werbach, 2012) • componentes del juego (Werbach, 2012) • sistema de recompensas (Pérez-Latorre, 2010) • sistema de feedback (EuropeanSchoolNet, 2009; Pérez-Latorre, 2010) • disponibilidad de instrucciones de juego (Katsaliaki y Mustafee, 2014) • posibilidad de guardar la partida (EuropeanSchoolNet, 2009)
5. DIDÁCTICA
• competencias (Lacasa 2011; LOMCE, 2015) • habilidades (Blooom, 1956) • condiciones de resolución de problemas (Lacasa 2011; Pérez-Latorre, 2010) • interdisciplinariedad • áreas de conocimiento/ adaptación curricular (EuropeanSchoolNet, 2009; Lacasa 2011) • necesidad de conocimientos previos • acompañamiento de guía didáctica

Tabla 3. Criterios preliminares de evaluación

Como se puede observar, la ficha de evaluación preliminar incluye variables de análisis (que también denominamos criterios de evaluación) diversas, tanto cuantitativas, que registran la frecuencia de ocurrencias de estas categorías, como cualitativas, que determinan la presencia o ausencia de ciertas categorías.

Tras la primera ronda, se empleó un segundo cuestionario para la recogida de información, estructurado en dimensiones con sus correspondientes variables de análisis y la valoración de estas variables en términos ordinales (importancia alta, importancia media, importancia baja). El análisis del cuestionario Delphi 2 dio lugar a un tercer cuestionario (Delphi 3) que analizó aquellas variables que no habían alcanzado consenso, y por lo tanto, se quedaban fuera del instrumento de evaluación. En esta ocasión, la valoración de las variables se hizo en términos dicotómicos (si/no) para que los expertos pudieran confirmar su posicionamiento a favor o en contra. La búsqueda del consenso ha sido el criterio básico para guiar el análisis de la información aportada por los expertos participantes en esta etapa del proceso, por este motivo, el cuestionario Delphi 3 contempla aquellas variables que presentaron un consenso mínimo, eliminando aquellas otras no compartidas por los participantes.

Fase 3: fase conclusiva

El proceso termina cuando se ha conseguido el grado de estabilidad, saturación y consenso deseado entre las opiniones de los participantes. Por tanto, el proceso se consideró cerrado cuando se les envió a los expertos las respuestas finales del grupo a través de un informe de cortesía que informaba de la propuesta de criterios resultante y que se estima definitiva.

4.1.6. Resultados: análisis de la información

Las opiniones aportadas por los expertos y el análisis descriptivo llevado a cabo en cada una de las rondas aportan una valiosa información desde diferentes perspectivas en este contexto. A continuación se presentan los resultados más relevantes,

Ronda Delphi 1

A la primera pregunta que se planteó a los expertos en esta ronda, acerca de las ventajas que puede tener el disponer de un instrumento validado de evaluación de juegos en línea centrados en contenidos sobre cambio climático (CC), las respuestas reflejan los

siguientes beneficios para los docentes en particular, y para las instituciones educativas en general:

1. Ampliar la visión de los aspectos relevantes a tener en cuenta por parte de los docentes a la hora de escoger los videojuegos.
2. Ahorrar tiempo docente al no tener que dedicar tiempo a la creación de materiales de calidad.
3. Sentar las bases para la creación de un repositorio útil de videojuegos de esta temática para utilizar en el aula o en otros entornos educativos, con criterios de clasificación "homologados" por especialistas en la materia.

Los expertos también valoraron como positivo el disponer de una herramienta de evaluación calibrada y validada que ofrece criterios a docentes, instituciones educativas, creadores, investigadores, agentes sociales y padres interesados en el cambio climático y les dota de argumentos fundamentados para la toma de decisiones en la elección de uno u otro juego, su interés, posibilidades de uso, estructura, funcionalidad, diseño y opciones de empleo de este tipo de recursos.

A la segunda pregunta, acerca de qué aspectos reestructurarían en la ficha preliminar (tabla 3) o qué otros criterios de evaluación añadirían, los expertos en general partieron de una opinión bastante favorable respecto a las dimensiones y criterios de evaluación. No obstante, plantearon apreciables propuestas tales como:

- sustituir el término dimensión-narratología por dimensión-narrativa, y el término dimensión-ludología por dimensión-jugabilidad
- integrar marcas enunciativas dentro del análisis narrativo
- trasladar los criterios nombre del productor, tipo de productor, público objetivo y finalidad comunicativa a la dimensión-identificación al tratarse de rasgos básicos que ayudan a reconocer el videojuego
- distinguir entre dimensión-narrativa y dimensión-contenidos para esclarecer las diferentes perspectivas del mensaje y sus contenidos
- añadir el criterio de emplazamiento en la Web para favorecer la localización del videojuego y determinar su usabilidad
- añadir el criterio "gratuidad" para dar a conocer esta circunstancia
- incluir el criterio de curva de aprendizaje para permitir determinar el grado de esfuerzo necesario para el aprendizaje y poder adaptar su uso al tiempo disponible en clase
- incluir el criterio de posibilidad de trabajo en grupo, muy útil debido a la falta de ordenadores en algunas aulas
- incluir el criterio de accesibilidad que permite calibrar el uso del juego para estudiantes con diversidad funcional
- añadir el criterio "posibilidad de evaluación del docente" para registrar cuáles son las posibilidades de integración en el aula, a través por ejemplo, del historial de acciones, registro de intervenciones del alumnado, entre otros.

Tras esa primera fase de consulta, la propuesta de instrumento de evaluación quedó reestructurada con las dimensiones y criterios que se muestran en la tabla 4.

DIMENSIÓN	DESCRIPCIÓN	CRITERIOS	
Identificación	Rasgos que ayudan a identificar y localizar el juego	-nombre del juego -URL -emplazamiento en la Web -disponibilidad de app -gratuidad -género del juego -idioma	-país de origen -nombre del productor -tipo de productor -público objetivo -finalidad comunicativa -breve descripción del juego
Narrativa	Análisis de las estructuras narrativas, estudio del juego como narración y como contexto en el que se establecen las condiciones para producir el mensaje	-relevancia de la narrativa -existencia de un narrador -historia global -historia por episodios	-representación del personaje -rol del personaje -representación del entorno -dimensión-espacio -dimensión-tiempo
Contenidos	Análisis del contenido del juego y los mensajes que se transmiten en torno al cambio climático, el cual puede revelarse a través de textos, audios, imágenes estáticas e imágenes dinámicas.	-concepto más empleado para CC -presencia de falsos conceptos-errores -uso explícito de fuentes de información -convergencia con redes sociales	-enfoque sobre el CC -temática principal -promoción de acciones -contextualización: causas -contextualización: consecuencias -tono del mensaje -imágenes empleadas
Jugabilidad	Análisis de las estructuras lúdicas del juego; estudio del juego como juego, en función de mecánicas, y de cómo su diseño produce significado.	-nº de jugadores, uso individual o colectivo -tipo de jugador -duración -niveles -interactividad -misión del juego: objetivos finales -misión del juego: objetivos instrumentales	-dinámicas -mecánicas -componentes -sistema de recompensas -sistema de feedback -disponibilidad de instrucciones del juego -posibilidad de guardar la partida.
Didáctica	Análisis del juego como recurso didáctico; estudio de los elementos pedagógicos y educativos.	-competencias -habilidades -condiciones de resolución de problemas -necesidad de conocimientos previos -curva de aprendizaje -posibilidad de trabajo en grupo	-accesibilidad -adaptación curricular -interdisciplinareidad -acompañamiento de guía didáctica -posibilidad de evaluación del docente

Tabla 4. Reestructuración de las dimensiones y criterios de evaluación tras la ronda Delphi 1.

Ronda Delphi 2

Con el fin de seleccionar aquellos criterios más relevantes y que mayor consenso hubieran alcanzado para la elaboración del instrumento final de evaluación de juegos, se pidió a los participantes que valoraran la importancia de cada uno de los criterios de evaluación en términos ordinales (1=importancia baja, 2= importancia media, 3= importancia alta), a través de un cuestionario. Los criterios pre-seleccionados fueron aquellos que habían alcanzado un consenso mayor del 90% de porcentaje acumulado de importancia media y alta. Este porcentaje representa un valor robusto de selección de criterios y a la vez discrimina con un margen de tolerancia del 10% las posibles discrepancias entre evaluadores.

Además, para obtener una mayor información acerca de la opinión de los expertos, se procedió a asignar una puntuación a cada uno de los criterios, lo que permitió establecer un ranking. Teniendo en cuenta que la importancia baja se valora con 1 punto, la media con 2 y la importancia alta con 3 puntos, y que en esta etapa participaron 11 de los 13 expertos invitados, la puntuación máxima para asignar a un criterio fue de 33 puntos. Aun teniendo un mismo porcentaje, algunos criterios obtienen una puntuación sumativa no coincidente debido a que su cálculo es resultado del sumatorio de valoraciones medias y altas: algunos criterios obtuvieron varias calificaciones de 3 y menor en 1.

La tabla 5 muestra, organizados en las cinco dimensiones de evaluación, los porcentajes de acuerdo total y la puntuación total para cada uno de los criterios, siendo ésta última la base en la que calcular el ranking.

CRITERIOS	PORCENTAJE ACUMULADO: importancia media y alta (CONSENSO 90%)	PUNTUACIÓN TOTAL	RANKING
IDENTIFICACIÓN			
nombre juego	100,00%	32	1º
finalidad comunicativa	100,00%	32	1º
tipo productor	100,00%	31	2º
idioma	100,00%	30	3º
público objetivo	100,00%	30	3º
breve descripción	100,00%	30	3º
disponibilidad app	90,90%	29	4º
URL	90,90%	28	5º
gratuidad	90,90%	27	6º
género del juego	81,80%	27	6º
emplazamiento web	90,90%	25	7º
nombre productor	72,80%	24	8º
país de origen	72,80%	23	9º
NARRATIVA			
dimensión-espacio	100,00%	31	1º
dimensión-tiempo	100,00%	30	2º
representación entorno	100,00%	29	3º
relevancia narrativa	90,90%	28	4º
existencia narrador	90,90%	27	5º
historia global	90,90%	27	5º
representación personaje	90,90%	27	5º
historia episodios	81,90%	25	6º
rol personaje	81,90%	25	6º
CONTENIDOS			
redes sociales	100,00%	32	1º
enfoque CC	100,00%	31	2º
temática principal	100,00%	30	3º
uso conceptos científicos	100,00%	30	3º

promoción de acciones	100,00%	29	4º
uso fuentes información	90,90%	29	4º
contexto-causas	90,90%	29	4º
conceptos empleados	100,00%	28	5º
tono mensaje	90,90%	27	6º
contexto-consecuencias	90,90%	25	7º
falsos conceptos	81,90%	25	7º
imágenes	63,60%	24	8º
JUGABILIDAD			
dinámicas	100,00%	32	1º
sistema de feedback	100,00%	31	2º
instrucciones disponibles	100,00%	31	2º
tipo jugador	90,90%	31	2º
número jugadores	90,90%	28	3º
duración	90,90%	28	3º
interactividad	90,90%	28	3º
sistema de recompensa	90,90%	28	3º
guardar partida	90,90%	28	3º
misión-objetivos finales	81,80%	27	4º
niveles	72,70%	26	5º
mecánicas	72,70%	26	5º
misión-objetivos instrumentales	72,70%	25	6º
uso individual o colectivo	81,80%	23	7º
componentes	72,70%	21	8º
DIDÁCTICA			
trabajo en grupo	100,00%	31	1º
guía didáctica disponible	100,00%	31	1º
conocimientos previos	90,90%	30	2º
evaluación del docente	90,90%	29	3º
resolución de problemas	90,90%	28	4º
curva aprendizaje	90,90%	28	4º
interdisciplinareidad	90,90%	28	4º
habilidades	90,90%	27	5º
accesibilidad	90,90%	27	5º
competencias	90,90%	25	6º
adaptación curricular	36,40%	17	7º

Tabla 5. Porcentajes de acuerdo total y ranking de criterios

Como se puede observar en la tabla 5, un total de 14 criterios no alcanzaron el consenso mínimo establecido del 90%. De los resultados se desprende que la dimensión donde hay menos discrepancia de opiniones acerca de los criterios de evaluación es la dimensión didáctica, mientras que la que genera más discrepancia es jugabilidad.

En relación a la identificación del videojuego, los criterios mejor valorados, ocupando los tres primeros puestos según el ranking generado, son los relativos a nombre del juego, tipo productor, finalidad comunicativa, público objetivo, breve descripción e idioma.

En la dimensión narrativa destacan los aspectos relacionados con la dimensión-espacio, dimensión-tiempo y representación del entorno, mientras que en la dimensión contenidos, los más valorados tienen que ver con la convergencia con redes sociales, el enfoque del cambio climático, el uso explícito de conceptos científicos así como el tema principal tratado.

Por su parte, las dinámicas, el sistema de feedback, las instrucciones disponibles, el tipo de jugador, la posibilidad de guardar la partida, el sistema de recompensa, la interactividad y la duración, son los aspectos que cobran mayor relevancia en la dimensión jugabilidad.

Finalmente, en la dimensión didáctica, destacan los criterios de disponibilidad de guía didáctica, el trabajo en grupo, la necesidad o no de conocimientos previos y la posibilidad de evaluación del docente.

En una visión de conjunto, el criterio peor valorado es el de adaptación curricular, seguido de componentes, uso individual-colectivo y país de origen de la producción del juego.

Por último, el análisis de los porcentajes de acuerdo parcial confirma que, en general, el grado de consenso fue alto, y que además, la mayoría de los criterios fueron valorados con un grado de importancia media-alta próxima al 90% (63,18% con valoración alta y 26,67% media), mientras que los valorados con importancia baja fue de un 10,15%.

Ronda Delphi 3

Para finalizar este proceso, tras la segunda ronda de consultas se solicitó a los expertos una valoración final de los 14 criterios que no superaron un consenso mínimo del 90% con el fin de calibrar discrepancias y confirmar la selección final de criterios que formarían parte del instrumento de evaluación de juegos en línea sobre cambio climático. Así, se llegó a alcanzar una mayor estabilidad en las respuestas tras la segunda etapa del proceso Delphi, y una reducción significativa de la variabilidad de las opiniones de los expertos. En esta ronda, el grado de participación disminuyó y sólo participaron 9 expertos, de los cuales tres eran expertos en comunicación, tres en educación y tres en videojuegos y gamificación. A la pregunta de si estaban de acuerdo en que los 14 criterios que no pasaron la segunda ronda se quedaran fuera del instrumento de evaluación, los resultados fueron los siguientes:

CRITERIOS	**TOTAL DE RESPUESTAS "SI"** **(Criterios quedan fuera de la muestra)**
país de origen	66,66%
nombre productor	66,66%
Componentes	66,66%
género del juego	55,55%
misión-objetivos instrumentales	55,55%

Mecánicas	55,55%
adaptación curricular	55,55%
historia episodios	55,55%
Niveles	55,55%
Imágenes	44,44%
rol personaje	33,33%
misión-objetivos finales	33,33%
falsos conceptos	33,33%
uso individual o colectivo	22,22%

Tabla 6. Respuestas totales de la ronda Delphi 3

Tal y como muestran los resultados, los expertos confirmaron sus posiciones como grupo y concluyeron por mayoría que los siguientes criterios de evaluación quedaran fuera del instrumento de evaluación de juegos en línea centrados en contenidos de cambio climático: género del juego, país de origen, nombre del productor, historia por episodios, niveles, misión- objetivos instrumentales, mecánicas, componentes y adaptación curricular.

En el caso de adaptación curricular, que obtuvo la puntuación más baja en la segunda ronda con 17 puntos (porcentaje acumulado de importancia media-alta del 36,40%), algunas de las justificaciones de los expertos para su exclusión fueron: "*el currículo a veces no está ni siquiera adaptado a las necesidades/intereses del adolescente según su desarrollo cognitivo*", "*la conciencia y la responsabilidad para con el planeta no tiene por qué tener correspondencia curricular*" o "*generalmente se busca este tipo de videojuegos ya con un objetivo curricular claro*".

Los argumentos de los participantes para mantener el resto de los criterios fueron los siguientes:

- Rol del personaje: *aporta matices para una radiografía más ajustada de los contenidos de la muestra; aporta información sobre la historia del juego; importante para entender tu papel como jugador en el juego.*
- Falsos conceptos: *es un elemento que puede afectar mucho a la calidad de los sistemas propuestos; identifica ideas erróneas sobre el cambio climático que puedan confundir al alumnado.*
- Imágenes: *aporta una idea aproximada del universo simbólico del juego.*
- Uso individual o colectivo: *hace referencia a la dinámica interna del juego y por lo tanto puede aportar matices; información fundamental para planificar actividades con el alumnado al evaluar la conveniencia del juego para su aula de acuerdo con los recursos de los que dispone en la misma; la implicación del jugador es distinta en uso colectivo, ya que permite competir.*
- Misión- objetivos finales: *hace referencia a la dinámica interna del juego y por lo tanto puede aportar matices; es un elemento importante para analizar lo divertido y motivador que puede llegar a ser el juego; conocer la meta impulsa el relato.*

Aunque los 3 grupos de expertos de distintos perfiles de nuestra pequeña muestra—3 expertos en comunicación, 3 en videojuegos y 3 en educación— coinciden en la eliminación de los 14 criterios en el instrumento de evaluación, el análisis de las respuestas específicas de esta última ronda para cada criterio pone de manifiesto ligeras diferencias entre los grupos en función del campo de especialización. Destaca el hecho

de que los expertos en educación y comunicación son los que más optan por volver a incluir nuevamente esos criterios de evaluación en la selección final, mientras que los expertos en videojuegos prefieren excluir la mayoría de ellos. De hecho, los 3 expertos en videojuegos, a diferencia de los otros dos grupos de especialistas, optan unánimemente por la exclusión de criterios de jugabilidad (tales como niveles, misión-objetivos instrumentales y componentes del juego) y, de forma mayoritaria también por la eliminación de criterios comunicativos, tanto de narrativa como de análisis de contenido. Cabe destacar cómo la mayor parte de los expertos en educación prefieren que el criterio de adaptación curricular se quede fuera, a pesar de ser un criterio más de la dimensión de didáctica, a diferencia de los expertos de comunicación que, en principio, optan por la inclusión de este criterio en el instrumento de evaluación. La tabla 7 muestra globalmente una correlación ligera en las valoraciones del conjunto de los criterios que hacen los expertos en videojuegos con los educadores y expertos en educación (r=0,44), mientras la mayor divergencia se aprecia entre los educadores y comunicadores que discrepan mayoritariamente en sus valoraciones de conjunto como lo muestra la ausencia de correlación (r=0,061).

Correlación Rho de Spearman			
	Expertos comunicación	Expertos videojuegos	Expertos educación
Expertos comunicación	1,000	,444	,061
Expertos videojuegos	,444	1,000	,399
Expertos educación	,061	,399	1,000

Tabla 7. Correlación sobre la exclusión de criterios

Tras esta tercera ronda de consultas, se consiguió acercar diferencias y alcanzar un consenso en la propuesta de instrumento para la evaluación de juegos en línea sobre cambio climático, el cual tras finalizar el proceso de validación por parte de los expertos, cuenta con un total de 51 criterios. Para una mayor comprensión y facilidad de uso del instrumento de evaluación, se agruparon los criterios de representación-rol del personaje y de dimensión espacio-tiempo en la dimensión narrativa. Asimismo, la perspectiva sobre cambio climático, temática principal, promoción de acciones, contextualización causas-consecuencias y tono del mensaje se incluyeron bajo el criterio marco del mensaje. La tabla 8 presenta el instrumento de evaluación con los criterios, una breve descripción de los mismos y opciones de respuesta.

1. IDENTIFICACIÓN
• **nombre del juego** • **URL** (página web) • **emplazamiento en la Web** (este criterio permite valorar su visibilidad online. La URL puede estar emplazada en una página web independiente, en una sección de la página web del productor/autor o en una sección de otra página web.) • **disponibilidad de aplicación para móviles** (el juego en línea puede disponer de una versión para móviles a través de una aplicación. En este caso, la página web incluye o informa sobre la opción de descarga de la aplicación) • **gratuidad** (se refiere a si el juego es gratuito o de pago) • **idioma** (lengua o lenguas que se emplean en el juego) • **tipo de productor** (tipo de entidad encargada de la autoría y producción del juego. Ejemplo: gobierno, ONG, empresa, instituciones científicas) • **público objetivo** (público al que está dirigido el juego, en función a intervalos de edad y

nivel educativo)

- **finalidad comunicativa** (se refiere a intencionalidad y objetivos comunicativos que persigue el juego: desarrollar familiaridad sobre el tema, impulsar conocimiento sobre causas y consecuencias, fomentar cambio de actitudes y comportamientos y/o estimular reflexiones y pensamiento crítico)
- **breve descripción del juego** (resumen del juego en función de su productor-destinatario, género, objetivos y contenidos)

2. NARRATIVA

- **relevancia de la narrativa** (los elementos narrativos pueden adquirir importancia o ser irrelevantes/ abstractos. La relevancia puede ser alta, media o baja)
- **existencia de un narrador** (el mediador que relata hechos)
- **historia global** (descripción del relato del juego en su conjunto, basado en la sucesión lógica o causal de hechos por un tiempo determinado)
- **representación y rol del personaje** (descripción de las características y cualidades del personaje-avatar. Ejemplo: estatus, ánimo, experiencia. El personaje puede tener desempeñar distintos roles. Ejemplo: alcalde, político, súper héroe, empresario, científico o ciudadano corriente)
- **representación del entorno** (descripción del mundo en el que se desenvuelve el personaje-jugador)
- **dimensión espacio/tiempo** (contexto general de los escenarios que aparecen en el juego. Ejemplo: global, nacional, regional o local; y periodo en el tiempo en el que transcurre la historia y en el que el personaje-jugador actúa. Ejemplo: pasado, presente o futuro)

3. CONTENIDOS

- **conceptos empleados** (terminología que más se usa en el juego para describir el fenómeno que estudiamos. Puede ser cambio climático o calentamiento global, cada uno de estos términos conlleva connotaciones en su significado)
- **presencia de falsos conceptos-errores** (existencia de conceptos e ideas erróneas en relación al fenómeno del cambio climático. Ejemplo: agujero de la capa de ozono, lluvia ácida, tsunamis)
- **uso explícito de conceptos científicos** (definición de términos y conceptos en relación al cambio climático)
- **uso explícito de fuentes de información** (se cita la fuente de información y datos)
- **convergencia con redes sociales** (se incluyen enlaces a redes sociales. Ejemplo: Facebook o Twitter)
- **marco del mensaje** (perspectiva sobre cambio climático -mitigación vs. adaptación-; temática principal –energía, agua, gestión de residuos, movilidad, consumo, biodiversidad, planificación urbana o riesgo de desastres naturales-; promoción de acciones; contextualización -causas y consecuencias-; y tono del mensaje, es decir, cómo se transmite el mensaje, los valores y emociones que se le otorga al tema abordado- alarmista, sensacionalista, informativo, incertidumbre, protesta, esperanzador, pro-acción, solidario, humor, proximidad o lejanía).
- **imágenes empleadas** (imágenes estáticas como fotografías e imágenes dinámicas como animaciones o vídeos

4. JUGABILIDAD

- **nº jugadores**
- **uso: individual vs. colectivo**
- **tipo de jugador** (el juego puede encajar en distintos perfiles de jugador: creador -preferencia por construir, diseñar, crear, personalizar, escoger-; competidor -preferencia

por ganar, comparar, desafiar; explorador-preferencia por descubrir, coleccionar, revisar, votar; colaborador- preferencia por comentar, compartir, dar, compartir con otros, formar comunidad-)

- **duración** (se refiere al tiempo empleado por nivel-misión o durante todo el juego. Ejemplo: menos de 30 minutos, más de 30 minutos o más de 1 hora)
- **nivel de interactividad** (grado de intervención, modificación y elección sobre el contenido por parte del usuario; puede ser alto, medio o bajo)
- **misión del juego- objetivos finales** (se refiere a las acciones esenciales para ganar el juego; responde a la pregunta cómo se gana el juego)
- **dinámicas del juego** (estructura general del juego, elementos que provocan la inmersión del jugador. Ejemplo: fantasía, desafío, compañerismo, pasatiempo, descubrimiento, habilidad, emociones, progresión o estatus)
- **sistema de recompensas** (este criterio evalúa las acciones que se incentivan, como apagar luces, desmantelar central nuclear, así como las propias recompensas, como las monedas virtuales o el desbloqueo de niveles)
- **sistema de feedback** (comentarios a través del texto, audio o audiovisual que recibe el jugador ante determinadas acciones; pueden ser positivos, negativos o ambos)
- **disponibilidad de instrucciones de juego** (guía interna o en formato pdf que nos indica paso por paso las acciones que debemos llevar a cabo para avanzar en un juego)
- **posibilidad de guardar la partida** (posibilidad de guardar la partida y reiniciarla cuando se desee)

5. DIDÁCTICA

- **competencias** (conocimientos y actitudes que alcanza el estudiante. Ejemplo: competencia en comunicación lingüística, competencia matemática, competencia en el conocimiento y la interacción con el mundo físico; tratamiento de la información y competencia digital; competencia social y ciudadana; competencia cultural y artística; competencia para aprender a aprender; autonomía e iniciativa personal)
- **habilidades** (operaciones mentales que alcanza el estudiante. Se trata de una pirámide que va de la habilidad más simple a la más compleja: recordar, comprender, aplicar, analizar, evaluar y crear)
- **condiciones de resolución de problemas** (tipo de razonamiento para resolver problemas: razonamiento reproductivo/memoria o productivo/creatividad)
- **necesidad de conocimientos previos** (esta necesidad se verá influenciada por el nivel de dificultad del juego)
- **curva de aprendizaje** (nivel de dificultad en el aprendizaje: alto, medio o bajo)
- **posibilidad de trabajo en grupo** (se refiere a la posibilidad de formar grupo de estudiantes en torno a los ordenadores ante la posible escasez de ordenadores en el aula)
- **accesibilidad** (disponibilidad del juego para estudiantes con diversidad funcional)
- **interdisciplinariedad** (combinación de dos o más disciplinas académicas, áreas de conocimiento)
- **acompañamiento de guía didáctica** (documento o enlace a información destinada a los docentes con consejos y sugerencias para implementarlo en el aula)
- **posibilidad de evaluación del docente** (el docente puede acceder a historial de acciones, registro de intervenciones, etc.)

Tabla 8. Propuesta de instrumento de evaluación

Se incluye una ponderación en función de la relevancia que los expertos dieron a cada uno de los criterios; de esta forma, no tendría el mismo peso un criterio que estuvo por salir del instrumento, que otro que obtuvo la totalidad de aceptación desde la primera fase del proceso Delphi. Dicha ponderación se ha llevado a cabo calculando el punto de corte del tercil 2, cuyo valor es 29; esta puntuación nos permite seleccionar todos

aquellos criterios que están en el tercer tercil. Los criterios que obtuvieron una puntuación igual o mayor de 29, por lo tanto, adquirieron una mayor relevancia por parte de los expertos. Éstos criterios son: nombre juego; finalidad comunicativa; convergencia con redes sociales; dinámicas del juego; tipo productor; dimensión-espacio; perspectiva sobre cambio climático; tipo jugador; sistema de feedback; disponibilidad de instrucciones; trabajo en grupo; disponibilidad de guía didáctica disponible; idioma; público objetivo; breve descripción; dimensión-tiempo; uso explícito de conceptos científicos; temática principal; necesidad de conocimientos previos; disponibilidad de app; representación del entorno; uso explícito de fuentes información; promoción de acciones; contexto-causas; y posibilidad de evaluación del docente.

La posible falta de tiempo de los docentes puede ser una limitación a la hora de usar cada uno de los criterios propuestos en la Tabla 8. Ante esta limitación, esta ponderación permite al profesorado una toma de decisión más objetiva y rápida a la hora de escoger un juego en línea sobre cambio climático para su uso en clase. Por lo tanto, en caso de no poder usar cada uno de los criterios para evaluar un juego, se recomienda hacer uso de aquellos criterios ponderados como más relevantes.

4.1.7. Conclusiones

El método Delphi nos ha permitido identificar y validar criterios de evaluación para juegos en línea centrados en contenidos de cambio climático, variables que permiten analizar esta herramienta desde una perspectiva comunicativa y educativa. El instrumento de evaluación propuesto contribuye a ampliar la visión de características relevantes a tener en cuenta a la hora de elegir un videojuego para usarlo en el aula y sentar las bases para la creación de un repositorio útil de juegos en línea sobre cambio climático en particular, y sobre temática medioambiental en general. Estos criterios validados pueden ser útiles no sólo para docentes sino también para investigadores, diseñadores de juegos y otros agentes sociales de todo el mundo. Además, puede servir como punto de partida para instrumentos de evaluación similares orientados a videojuegos de otras materias y temas.

De este proceso de recogida de información, análisis y discusión cabe destacar el grado de representatividad de los expertos, en relación con el nivel educativo, ejercicio profesional y dominio del tema. Se alcanzó un alto consenso entre los expertos en la selección de criterios durante la segunda ronda de consultas, sobre todo aquellos relacionados con narrativa, contenidos y didáctica. Se produjo una valoración positiva acerca de la importancia de los criterios propuestos, con un 63,18% de los criterios valorados como “muy importantes”. Además, globalmente se produjo un aceptable grado de coincidencia en sus opiniones acerca de la eliminación de los 14 criterios en el instrumento de evaluación. Esta coincidencia se ve respaldada por una moderada correlación entre las valoraciones que hacen los expertos en videojuegos respecto a los otros dos grupos de evaluadores, mostrando ausencia de correlación entre las valoraciones que hacen educadores frente a comunicadores.

Por otro lado, reconocemos como limitación en este estudio el descenso gradual de participación a lo largo del proceso, de 13 en la primera ronda a 9 en la última, debido probablemente al periodo vacacional con el que coincidió una de las rondas de consulta.

Recomendamos usar el instrumento de evaluación que hemos diseñado en su conjunto, aplicando todos los criterios de evaluación, pero también existe la posibilidad de hacer uso de aquellas dimensiones o criterios de evaluación que más se ajusten a las necesidades del evaluador. Además, es recomendable tomar ejemplos y capturas de imagen para una completa evaluación de los juegos. Ante la posibilidad de falta de tiempo de los docentes para hacer uso de cada uno de los criterios propuestos a la hora de evaluar un juego, el trabajo concluye con una propuesta de ponderación en función de la relevancia de los criterios, lo que permite a los docentes evaluar los juegos de forma más rápida usando aquellos criterios que fueron considerados más importantes.

Futuros estudios en relación con este tema deberían ir encaminados a aportar información precisa sobre cómo aplicar cada uno de los juegos, tanto en clase y contextos de educación formal, como en ambientes más informales como pueden ser museos o programas extra-escolares. Otra pregunta que surge de esta investigación es cuál es el impacto de estos juegos en línea sobre cambio climático sobre los jóvenes, cómo perciben los mensajes y si hay efectos en el comportamiento a largo plazo. El reto principal que tienen en común estos juegos es que el usuario traspase el mundo de la ficción del juego, mostrando que lo que han vivido a través del juego es una realidad y que las acciones que han experimentado ofrecen soluciones reales al problema del cambio climático.

4.1.8. Referencias

Aguaded-Gómez, José Ignacio (2011). "Niños y adolescentes: nuevas generaciones interactivas", *Comunicar*, vol. *36, núm.* XVIII, pp. 7-8.

Aparici, Roberto y Silva, Marco (2012). "Pedagogía de la Interactividad", *Comunicar,* vol. 38, núm. XIX, pp. 51-58.

Astigarraga, Eneko (2008). *El método Delphi*. San Sebastián: Universidad Deusto.

Bloom, Benjamin (1956). *Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain*. New York: David McKay Co Inc.

Bofferding, Laura y Kloser, Matthew (2015). "Middle and high school students' conceptions of climate change mitigation and adaptation strategies", *Environmental Education Research*, vol. 21, núm. 2, pp. 275– 294.

Bogost, Ian (2006). *Persuasive Games*. Cambridge, Londres: MIT Press.

Cooper, Caren (2011). "Media Literacy as a Key Strategy Towards Improving Public Acceptance of Climate Change Science", *BioScience,* vol. 61, núm. 3, pp. 231-237.

Díaz-Nosty, Bernardo (2013). "Aproximación a la construcción interdisciplinar y de un Nuevo paradigma. Comunicación, cambio climático y crisis sistemática", *Razón y Palabra*, vol. 84.

European SchoolNet (2009). *How are digital games used in schools.* Brussels: European Schoolnet.

Frasca, Gonzalo (2007). *Play the Message: Play, Game and Videogame Rhetoric.* Tesis doctoral, IT University of Copenhagen.

Gee, James Paul (2004). *Lo que nos enseñan los videojuegos sobre el aprendizaje y el alfabetismo.* Archidona: Aljibe.

Gónzalez-Gaudiano, Edgar y Meira-Cartea, Pablo Ángel (2009). "Educación, comunicación y cambio climático. Resistencias para la acción social responsable", *Trayectorias,* vol. 11, núm. 29.

Grifeu, Arnau (2010). *El documental interactivo. Evolución, caracterización y perspectivas de desarrollo*. Barcelona: Editorial UOC.

Juul, Jesper (2005). *Half-Real: videogames between real rules and fictional worlds.* Cambridge, MA: The MIT Press.

Katsaliaki, Korina y Mustafee, Navonil (2014). "Edutainment for Sustainable Development: A survey of Games in the Field", *Simulation y Gaming,* vol. 1, núm. 26.

Kim, Amy Jo (2012). *Social engagement: who´s playing? How do they like to engage*? Disponible en: http://goo.gl/BFTnhh

Lacasa, Pilar (2011). *Los videojuegos: aprender en mundos reales y virtuales*. Madrid: Ediciones Morata.

León, Bienvenido (2013). *El periodismo ante el cambio climático. Nuevas perspectivas y retos*. Barcelona: UOC.

Liarakou, Georgia; Sakka, Eleni; Gavrilakis, Costas; y Tsolakidis, Costas (2012). "Evaluation of serious games, as a tool for education for sustainable development", *EURODL (Special issue)*, pp. 96-110. Disponible en ERIC.

Linstone, Harold. A., y Turoff, Murray (1975). "Introduction", en H. A. Linstone, y M. Turoff (Eds.), *The Delphi method: Techniques and applications,* Reading, MA: Addison-Wesley Publishing Company, pp. 3-12.

Liu, Sanya y Ding, Wan (2009). "An approach to Evaluation Component Design in Building Serious Games", en M. Chang, R. Kuo, G.-D. Chen y M. Hiroshe (Eds.), *Edutainment ´09 Proceedings of 4th International Conference on E-learning and Games: learning by playing*, Berlin: Springer, pp. 141-148.

LOMCE - *Ley Orgánica para la Mejora de la Calidad Educativa* de 2015. Orden ECD/65/2015, de 21 de enero

Martí-Parreño, José; Méndez-Ibáñez, Ernesto; Giménez-Fita, Elisa y Queiro-Ameijeiras, Carmen (2015). "El uso de la gamificación en la educación superior: propuesta de una ficha de análisis ludológico-narratológico", en M.A Ruiz Rosillo (Ed.), *XII Jornadas Internacionales de Innovación Universitaria Educar para transformar: Aprendizaje experiencial,* Madrid: Universidad Europea de Madrid, pp. 103-111.

Meira-Cartea, Pablo Ángel (2008). *Comunicar el cambio climático. Escenario social y líneas de actuación.* Madrid: Ministerio de Medio Ambiente y Medio Rural y Marino-Organismo Autónomo de Parques Nacionales. Disponible en:
http://www.magrama.gob.es/es/ceneam/recursos/documentos/comunicar_cc_completo_tcm7-13513.pdf

Meira-Cartea, Pablo Ángel; Arto-Blanco, Mónica; Iglesias da Cunha, Francisco Heras; Lorenzo-Castiñeiras, Juan José; y Montero-Souto, Pablo (2013). *La respuesta de la sociedad española ante el cambio climático 2013*. Madrid: Fundación Mapfre / Aldine Editorial.

Moser, Sussane (2010). "Communicating Climate Change: History, Challenges, Process and Future Directions", *WIREs Climate Change,* vol. 1, pp. 31-53.
Moser, Sussane y Dilling, Lisa (2011). "Communicating Climate Change: Closing the Science-Action Gap", en J.S. Dryzek, R.B. Norgaard, y D. Schlosberg (Eds.), *Oxford Handbook of Climate Change and Society*, Oxford: Oxford University Press.

Murray, Jane. (1999). *Hamlet on the Holodeck*. Cambridge, MA: The MIT Press.

Pérez-Latorre, Óliver (2010). *Análisis de la significación del videojuego. Fundamentos teóricos del juego, el mundo narrativo y la enunciación interactiva como perspectivas de estudio del discurso.* Tesis doctoral, Universidad Pompeu Fabra. Disponible en: http://www.tesisenred.net/bitstream/handle/10803/7273/topl.pdf?sequence=1

Piñuel-Raigada, José Luis (2013). "El discurso hegemónico de los Media sobre el Cambio Climático (Riesgo, Incertidumbre y Conflicto) y estrategias de intervención", en VV. AA (Eds.), *Medios de Comunicación y Cambio Climático,* Sevilla: APIA, pp.13-33.

Pozo-Llorente, Mª Teresa; Gutiérrez-Pérez, José; y Rodríguez-Sabiote, Clemente (2007). "El uso del método Delphi en la definición de los criterios para una formación de calidad en animación sociocultural y tiempo libre", *Revista de Investigación Educativa*, vol. 25, núm.2, pp. 351-366

Prensky, Marc (2001). "Digital natives, digital immigrants", *On the Horizon*, vol. 9, núm. 5, pp. 1-6.

Reckien, Diana y Eisenack Klaus (2013). "Climate Change Gaming on Board and Screen: A review", *Simulation and Gaming,* vol. 44, núm. 2-3, pp. 253-271.

Scapolo, Fabiana y Miles, Ian (2006). "Eliciting expert´s knowledge: a comparison of two methods", *Technological Forecasting and Social Change,* vol. 3, pp. 670-704.

Taylor, TL (2006). *Playing between worlds: exploring on-line game culture.* Cambridge, Londres: MIT Press.

Tejeiro-Salguero, Ricardo; Pelegrina del Río, Manuel; y Gómez-Vallecillo, Jorge Luis (2009). "Efectos psicosociales de los videojuegos", en Ramos, M. y Pérez (eds.), *Videojuegos y Comunicación: hacia el lenguaje del videojuego*, *Comunicación*, núm. 7, Universidad de Sevilla. pp. 235-250.

Tejeiro-Salguero, Ricardo y Pelegrina del Río, Manuel (2003). *Los videojuegos: qué son y cómo nos afectan*. Barcelona: Ariel

Werbach, Kevin y Hunter, Dan (2012) *The gamification toolkit. Dynamics, mechanics and components for the win.* Pennsylvania: Wharton Digital Press.

4.2. Analysis of individual online climate change games targeting youth: proposing a checklist and exploring opportunities

Article 2: Ouariachi, T., Olvera-Lobo, M.D. & Gutiérrez-Pérez, J., (2017). "Analysis of individual online climate change games targeting youth: proposing a checklist and exploring opportunities". *Revista Electrónica de Investigación Educativa* (REDIE), 19 (2) (in press)

Online games have been proposed as a promising tool for communication and education. Taking into account the new communicative paradigm of youth and that climate change is one of the main threats to their future, this paper presents a checklist of validated indicators through the Delphi method to analyze communicative elements of online climate change games and it illustrates its use and usefulness with a qualitative analysis of a sample of games produced in Spain. This exploratory study maintains that online climate change games are shaping themselves as innovative strategies, thanks to their immersive narrative and interactivity among other features, by facing the communicative and educational challenges regarding climate change: causes are made visible, actions are portrayed as local, uncertainty is avoided, contextualized information is provided with positive and pro-action tone, and a critical thinking approach is encouraged through decision-making.

4.2.1. Introduction

The fight against climate change requires a new form of social action in which young people are called upon to make a difference. If youth are to protect their future planet from climate change, they should be knowledgeable on the topic and motivated to take climate-friendly actions. Despite the urgency of the matter, recent surveys on the perception of climate change in Europe show that knowledge of the issue is still limited and a notable lack of commitment to adopting measures for mitigating and adapting to climate change can be seen (European Commission, 2011).

Traditional education programs face challenges to adapt to the teenagers´ information processing styles, reason why high schools are in search of ways to modernize their methods for knowledge transfer. By taking young people as an objective sector of the population, it would be logical to put forward strategies that correspond with the new communicative paradigm of the "interactive generations" (Aguadez-Gómez, 2011) or the "digital natives" (Prensky, 2001), who have grown up in a world surrounded by computers, the Internet and videogames, and have mastered concepts such as interaction, participation and collaboration.

The change in the mode of interaction means that existing communicative paradigms need to be revised and that there is a need to move towards new formats that facilitate a natural interaction between the person, the interface and the environment (Garrido-Miranda, 2013). Videogames in general, and online games in particular, can offer this possibility. In fact, videogames allow players to become involved in decision-making processes, in past, present and future scenarios, participating in the creation of the plot and, therefore, in the construction of the narrative, becoming "integral symbolic subjects" (Marcos & Satorum, 2014). For this and other reasons, videogames have been proposed as a promising communication and education tool, able to strengthen learning in an interactive way.

Online games can offer the possibility to be implemented in educational contexts as a didactic tool for teachers: well-designed games foster skills and abilities, contribute to content development and permit learning experiences that aren't possible in real life (Gee, 2004). Under the paradigm of "game-based learning", several projects using online games have been implemented successfully to address climate change in high schools, key places to consume information and reach youth audience (Flora et al. 2014; Knol & De Vries, 2011). There is strong interest in the educative community; however, teachers still lack information on the nature of these resources according to a research carried out by the European Network for Growing Activity in Game-based learning in Education (ENGAGE).

Despite the increase of projects in the last decade, the field of climate change online gaming is still far from being mature. There is a need to understand more their nature and communicative characteristics. This could help teachers deciding appropriate games as pedagogical resources. Although discussions have begun on the analysis of such games and several criteria have been proposed (Liarakou et al., 2012; Liu & Ding, 2009; Martí-Parreño et al., 2014), most sets of criteria focus only on pedagogical aspects, ignoring the communicative elements. We also observe how the majority of studies, initiatives and projects address English-speaking games, paying little attention to contributions in other languages, such as Spanish. This study aims to bridge these gaps.

Under these premises and considering climate change as one of the main challenges facing humanity in general and young people in particular, this article aims a) to present a checklist with validated analysis indicators; b) to analyze the communicative elements of a sample of online climate change games, illustrating the use and usefulness of the proposed indicators; and c) to explore opportunities of these type of games for climate change communication and education among young people. To do this, we firstly address the importance of climate change communication and education, the concepts of climate change related online games, and we subsequently carry out a qualitative analysis of a representative sample of online climate change games produced in Spain, as a case study, in order to support literature review and arguments with examples.

4.2.2. Climate change communication and education

Communication and education on climate change play an important role in the process of behavior and lifestyle change, translating the complexity of the problem and the need to intervene in several sectors. If environmental communication can be defined as exchanging messages to promote sustainable knowledge, attitudes and behaviors, communication in favor of the climate must address exchanging persuasive messages to promote pro-environmental actions aiming at reducing greenhouse gasses emission (Castro, 2010).

Several studies have confirmed that most climate communications efforts have failed until now and not necessarily because of little information being available; among other limitations in delivering information, scholars acknowledge the one-way transmission of messages, the lack of contextualization, and the negative and alarmist tone of the content (Aparici & Silva, 2012; Bienvenido et al., 2013; Cooper, 2011; Díaz-Nosti, 2013; Moser, 2010; Shafer, 2012). Authors like Sheppard (2012) has proposed a simple formula for effective climate change communication: (1) make it local, (2) make it

visual, and (3) make it connected. This communicative approach must be taken into account in the design and development of educational programs on climate change, which must address the conceptual understanding of the problem, awareness on the importance of the problem, and the need to take actions to reduce greenhouse gasses emission.

Since the second half of the 20th century, serious critics to the pedagogical model have been raised because of its unidirectionality, based in communicative models that divide transmitter and receiver of the information (Aparici & Silva, 2012). Broadly, the literature suggests that future education efforts include interactive learning and consideration of the individual within their socio-cultural contexts (Cordero, Todd, & Abellera, 2008; McKenzie-Mohr, 2008). In addition, there is a need to add a critical approach to environmental education, opening spaces for reflections and debates about possible alternatives for change in relation to our lifestyles (Cooper, 2011; Michael & Savill-Smith, 2004). Climate change education that includes awareness, knowledge, skills, values and opportunities for participation can therefore bring about in-depth learning.

4.2.3. Defining online climate change games

Unlike television or film, where the viewer is simply a passive consumer of information, with videogames the user experiments for his/herself and plays different roles through characters or avatars from perspectives which would otherwise be impossible. For videogame, we take the definition by Tejeiro & Pelegrina (2003), who describe it as electronic game which uses computer technology and allows a player to interact with the machine in real time, and in which action takes place in a visual format. Online games, on the other hand, are a type of videogame with a unique feature in that they are accessed via a web browser and they are available on the Internet. In this paper we will use the terms *videogames* and *online games*, interchangeably.

Despite the fact that some authors do not include educational videogames (for teaching and learning purposes) within videogames (for recreational purposes), in this paper it is held that in educational videogames the recreational component is ever greater, which is why they should be considered as such. The gamer intends to have fun and be entertained, but at the same time they are developing abilities and knowledge, particularly where the theme of the game is serious, as is the case with climate change. These types of videogames, which go beyond fun and involve communicative and educational purposes, have also been called "serious games" (Katsaliaki & Mustafee, 2014).

Therefore, when talking about "online climate change games" we are focusing on games specifically themed around climate change with communicative and educational purposes which involve fun and entertainment, and which are available on the Internet. These games usually have communicative objectives such as a) developing familiarity with and knowledge of the topic, b) raising awareness of causes and consequences, c) stirring emotions and reflections, d) stimulating the development of ideas and solutions and e) promoting a change in attitudes and behaviour.

As can be inferred from the definitions above, we are dealing with a digital environment characterised by two fundamental aspects: interactivity and immersion. Whereas

interactivity can be thought of as a conjunction between sequentiality (a basic characteristic of computers when executing a series of commands) and participation (ability to cause behaviours that intervene to modify those sequential processes), immersion can be defined as "the part that allows us to add dramatic aspects to our relationship with the computer" (Murray, 1999, quoted in Grifeau, 2013, p.109).

4.2.4. Methodology

Online climate change games on the web were compiled, selected and analysed making use of a checklist with validated analysis indicators. The analysis of the sample of games not only helps to have a better idea of the nature and communicative characteristics of online climate change games, and how they may contribute to effective communication and education among young people, but it also helps to illustrate the use and usefulness of the validated analysis indicators. Following a qualitative methodology, below we describe the steps and the instruments used:

Establishment of a checklist with validated indicators

In order to obtain information on online climate change games in a systematic manner, a data collection checklist was drawn up. Firstly, analysis indicators were identified through a bibliographic review (European SchoolNet, 2009; Lacasa 2011; Grifeau, 2012; Katsaliaki, 2014; Meira-Cartea, 2007; Moser, 2011; Pérez-Latorre, 2010; Piñuel-Raigada., 2013; Reckien and Eisenack, 2013; Werbach, 2012). These analysis indicators were divided into four dimensions: identification (features that help identify and locate the game); narrative (analysis of the narrative and expository structures); contents (analysis of the content and messages transmitted about climate change); and gameplay (analysis of the game design and how this produces meaning).

The division of the indicators in these four dimensions is inspired in the "Social Discourse of Videogames Analysis Model" from Pérez-Latorre (2010). This perspective encompasses a narratological view of the game, which sees this medium as a form of narrative and a way of telling stories, and also ludological view, which takes into account the rhetoric that hides the design of the dynamic, mechanisms and elements of the game and how its design creates meaning.

Secondly, in order to validate the checklist, the analysis indicators were shared, via email, with a panel of 13 experts from Spain, Latin America and the USA in the fields of climate change, scientific communication, journalism, environmental education and videogames, in order for them to give their opinion on the relevance, use and usefulness of the indicators. They were selected for their theoretical and practical expertise, their motivation and their ability to be approached.

In this process, we made use of the Delphi technique, a systematic and interactive process aiming to obtain group opinions and consensus (Scapolo & Miles, 2006). In our case, three consulting cycles were sufficient: in the first round, an open question was sent to the experts to assess the preliminary checklist with indicators identified through the literature review and to propose new indicators; in the second round, a closed questionnaire was used to assess the usefulness of each of the items in ordinal terms (high, medium and low); and finally, an open question was posed to the experts to

confirm their positioning. The level of saturation was established by the consensus (90% between medium and high usefulness) and stability of the results.

For the purpose of this study, the following indicators were selected for the checklist through the Delphi technique.

Dimensions	Analysis indicators
Identification	• game title • URL: *link to the website* • type of creator: *author behind the creation of the game and type of institution* • communicative purpose: *communicative intentions and objectives of the game* • brief description: *summary according to the genre, objectives and back story*
Narrative	• relevance of narrative: *narrative elements can acquire importance or be irrelevant* • global storyline: *the story in its entirety, the logical or causal succession of the events* • character depiction and role: *characteristics and qualities of the character/avatar* • representation of the environment: *the world in which the character/player develops* • dimension/space/scale: *general context and scale of the scenarios* • dimension/time: *period in time that the story spans*
Contents	• term used: *terminology used to describe the phenomenon being studied* • explicit use of scientific concepts: *definition of climate change terms* • explicit use of information sources: *the sources of information and data are cited* • convergence with other media or social networks: *links to social networks are included* • message framework: *themes, causes/consequences and tone*
Gameplay	• degree of interactivity: *user intervention in the content* • dynamics: *structure, rules and basic elements* • player type: *players' profile depending on their interests* • feedback system: *message that the player receives in light of certain actions* • reward system: *actions that incentivise and the rewards themselves*

Table I. Dimensions and analysis indicators in the checklist

Compilation, selection and analysis of games

A web search was carried out in the time period August-December 2015 in the main search engines formulating the following search request: ("videogame" OR "online game" OR "educative game" OR "eco-game") AND ("climate change" OR "global warming" OR "sustainability" or "environment"), in Spanish. Particular emphasis was placed on searching climate change-related government and NGO directories, as well as websites specializing in education 2.0 and videogames.

In order to identify a sample of online climate change games produced in Spain, with a medium-high level of interactivity and a meaningful climate change storyline, the following requirements were taken into account: that they are hosted on a web platform and are free to access; that they are played over the Internet; that they have communicative and educational objectives; that the focus of the storyline is climate change, thereby excluding those in which this topic is an additional or lesser aspect of games that focus on topics that cross over with climate change – recycling, energy efficiency, sustainability; and that they are aimed at an adolescent audience (12+). In addition, snowball and interviews with key users from online videogame communities were also employed to identify the following games: 1. Actúa con tu consumo / *Act on your consumption;* 2. Alerta CO2 / *CO2 Alert;* 3. Climántica; 4. Misión posible, salvar el planeta / *Mission possible, save the planet;* 5. My Green Energy Planet

Taking into account that the subject matter is videogames, two researchers took part in the coding of the material making use of Table I. Levels, missions and episodes were used as analysis units, similar to scenes in movies or strip-frames in comics. In complex games, the researchers had to play the game several times to register data in a proper manner.

4.2.5. Results

By making use of the analysis indicators shown in Table 1, we begin a qualitative analysis to explore the communicative elements of a sample of games produced in Spain, while illustrating the use and usefulness of the indicators. The main observations are as follows:

Firstly, our analysis on the identification dimension (Table II) shows that NGOs are the main messengers, in charge of releasing the games and produce their messages. When looking at the communicative purpose, the majority of the games aim at developing familiarity with the topic, followed by raising awareness on causes and consequences, promoting attitude changes, and lastly, promoting the development of ideas and solutions for climate change through creativity. This last purpose is especially interesting they way is exposed in the game *Act on your consumption*, where the character Eva suggests that the player look around and check how many items are made of plastic in order to encourage the player to reflect and think how they can be substituted. She also encourages the player to write down his/her own plans for a sustainable diet and mobility low in CO2.

Name of the game	URL	Creator	Communicative purpose	Brief description
Actúa con tu consumo / *Act on your consumption*	http://consumo.greenpeace.es/	Greenpeace España	Develop familiarity with the topic; raise awareness causes-consequences; promote attitude changes; foster reflections	Diverse mini-games, tests and activities that promote critical and responsible consumption, which encourage the player to reflect on the impact of our actions on the environment
Alerta CO2 / *CO2 Alert*	http://www.accionatura.org/joc AlertaCO2/index.html	Acción Natura / Subsidised by the Autonomous Government of Catalonia	Develop familiarity with the topic; raise awareness causes-consequences; promote attitude changes	The player finds diverse mini-games in a virtual city that is getting more or less polluted depending on the decisions taken; the objective is to create awareness of CO2 emissions
Climántica	http://xogo.climantica.org/?locale=es	Xunta de Galicia / Climántica Environmental Education Project	Develop familiarity with the topic; raise awareness causes-consequences; promote attitude changes; foster reflections	Simulation game where the player has to create and manage a sustainable territory, planning actions in a strategic way and being aware of causes and consequences of climate change
Misión posible, salvar el planeta / *Mission possible, save the planet*	http://www.cruzroja.es/juego_cambio_climatico/	Cruz Roja Española / Subsidised by the Ministry for the Environment	Develop familiarity with the topic; raise awareness causes-consequences; promote attitude changes	Players become ecological superheroes who fight against the uncontrollable emission of greenhouse gases that contribute to climate change into the atmosphere, by completing several mini-games and tests
My Green	http://ww	Fundación AXA +	Develop familiarity	Simulation game created to raise

Energy Planet	w.wwf-spainsites.com/mygreenenergyplanet/	WWF España	with the topic; raise awareness causes-consequences; promote attitude changes	awareness and change the energy model to mitigate the effects of climate change. To do so, the player has to convert a city into a sustainable place

Table II. Findings on the identification dimension

Secondly, from the qualitative analysis of our sample we observe very diverse storylines, character depictions and representation of environments (Table III). For instance, in the game *Alert CO2*, the players play the role of normal citizens and are placed in the fictitious city of Metropolis, where they can choose between different scenarios, such as roads, schools or houses, where CO2 emission needs to be reduced and the player needs to work quickly to stop the warming of the planet through tests based on questions and other ability skills. Time runs and the player has to take decisions under time pressure. Similarly, in the game *Act on your consumption*, the player plays a role of a ordinary teenager and browses through different settings in the city, such as a supermarket, a house, a youth centre or a road, choosing between different areas in which to explore the connection between the impact of our consumption habits and our actions and the environment, through a series of activities.

In *Climántica*, the player decides to leave for a new territory and can choose between an inland territory, a rugged territory that gives way to the open sea, and a coastal territory. This first choice allows the user to place him/herself in a meaningful location, thereby adapting communication to the user's own context and interests. In the area chosen, the player becomes the major of a sustainable territory and creates houses and work for the population, builds leisure areas, experiments with energy, decodes messages, overcomes skill-based tasks and, above all, controls pollution and changes to the climate; as in *Alert CO2*, the player is situated in the present time at the beginning of the game, and time continues during the game until the player is situated in the year 2050 and is able to see the consequences of his/her actions in the past.

	Act on your consumption	***CO2 Alert***	***Climántica***	***Mission possible, save the planet***	***My Green Energy Planet***
Relevance of narrative	High	High	High	High	High
Global storyline	Eva is a young activist, aware of her power as a consumer and her impact on climate change. In different scenarios, she explores her city, analyze the problems and search for solutions	Excess in the emission of CO2 has warmed the atmosphere. The player must find solutions to daily activities and stop global warming	Many people are moving to a new territory because of the pollution of their homeland. During 20 years, the major must create a sustainable territory	Humanity is in a decisive moment for survival, greenhouse emissions are a threat. Ecological superheroes are fighting against climate change	Virtual world where a major is expected to take actions in order to keep environmental, energetic and social balance
Character depiction and role	Eva is a young activist from Greenpeace, committed with environment and society. Ironic	Ordinary young citizen	Major	Superheroes, 3 males and 3 females with superpowers like convincing abilities	Major

	and critical.				
Representation of the environment	Ordinary city, uncomfortable, polluted and full of traffic. Many protests from citizens take place.	Metropolis is a city with different pollution sources; it appears deserted. The smoke from industries are highly visible.	Inland territory crossed by a valley; territory close by the sea; coastal territory with sand and grass areas	Planet with a high level of danger caused by climate change	City with a high level of development, airport, harbor, , shopping malls, etc. The territory is often affected by strong wind and rain
Dimension/space/scale	Fictitious/ local	Fictitious/ local	Fictitious/ local	Real/ global: Andes, African Desert, Caribbean Sea	Fictitious/ local
Dimension/time	Present	Present-future	Present-future	Present-future	Present-future

Table III. Findings on the narrative dimension

Despite the diversity of storylines in the games, all games tend to provide a better description of the environments than of the characters, partly because of the nature of the climate change topic. Using a local discourse is one of the trends observed, a general preference towards portraying an ordinary citizen and focusing on the local scale. Players must make decisions at home or within their communities to reduce carbon emissions. Using a present-time discourse is another trend, but with lots of references to the future. Through this present-future connection, online games try to offer opportunities to convey to young people the problems that they will be facing in the future and enable them to experience them directly through the game.

Looking at the third dimension of the checklist (Table IV) and placing emphasis on the content of the story itself, the analysis of the communicative characteristics of our sample of online games illustrates the capacity of these communication tools to frame the story in a different way to conventional media, by addressing topics such as consumption, citizen mobilisation, and solidarity. In fact, consumption and limits to the growth of our system are aspects that traditional media have not been able to exploit in terms of the information coverage regarding climate change, perhaps due to the fact that the media itself form part of the central core of this system in crisis, as Díaz-Nosty (2013) states.

In the games analyzed, we have found some references and actions promoted supporting a less consuming society: eating less meat, consuming products from local stores and farmers, or shopping for products labeled environmentally-friendly. Consumption is at the end of a chain of many problems related to the environment in general, and to climate change in particular (Gónzalez-Gaudiano & Meira-Cartea, 2009).

	Act on your consumption	***CO2 Alert***	***Climántica***	***Mission possible, save the planet***	***My Green Energy Planet***
Terms used	Climate change	Global warming	Climate change	Climate change	Climate change
Explicit use of scientific concepts	Climate change, sustainable development,	Global warming, climate change, greenhouse	Intensive agriculture, greenhouse effect, sustainable	No	Biomass, geothermic energy, composting

		effect	development, renewable energy		
Explicit use of information sources	IPCC reports, video of "Age of Stupidity", websites	No	No	No	No
Convergence with other media or social networks	Facebook and Twitter	Facebook and Twitter	No	No	Facebook and Twitter
Message framework	Topics: consumption, citizen participation, waste management, transport. Causes: high GHG emissions Consequences: environment, health and society Message tone: pro-action, protest, ethical, proximity, directness	Topics: energy, disaster risk, waste management, transport and mobility. Causes: high emission of CO2 Consequences: extreme weather events, sea level rise, glacial melting. Message tone: alarmist, ethical, pro-action, informative	Topics: urban planning, energy, water, waste management, adaptation Causes: high GHG emissions Consequences: temperature rise, extreme weather events, ecosystem threats Message tone: pro-action, ethical, alarmist, protest	Topics: biodiversity, energy, transport and mobility Causes: high GHG emissions Consequences: ecosystem threat, extreme weather events, desertification Message tone: alarmist, pro-action, informative, hope, humour	Topics: urban planning, energy, water, waste management, transport, adaptation Causes: energetic model in society Consequences: temperature rise, desertification, economy Message tone: pro-action, ethical, alarmist, informative

Table IV. Findings on the contents dimension

Not only do videogames allow the player to immerse themselves in a virtual world with thematic frameworks different to those offered by the traditional media, but also the games analysed provide a story with more context, with causes and consequences. They have an alarming, but also proactive, hopeful and positive tone, avoiding uncertainty and sensationalism. Here are a couple of examples that represent the common message tones:

- Pro-action: "act quickly, your decisions can reduce CO2" (*CO2 Alert*)
- Directness: "Hi, I'm Eva, a young consumer like you" (*Act on your consumption*)

The messages they send out emphasise solutions, promoting individual action such as the use of bicycles, the use of renewable energy, the use of energy-saving light bulbs, waste management, buying unpacked goods or the organisation of citizen movements. Thus, the common conception that "our personal action is irrelevant given the scale of the problem and collective inaction", is substituted for the conviction that "without the involvement of everyone, adopting individual changes, taking part in the search for collective solutions and demanding changes to structural climate change policies, it will be difficult to make effective changes" (Meira-Cartea, 2008).

It is also worth noting 1) the preference among game creators for the term "climate change" over "global warming": based on British journalist Steven Poole's book

Unspeak (Poole, 2006), which investigates the manipulative power of language, climate change is a "less threatening" way of saying global warming and "less obviously" related to the oil industry; 2) the explicit use of scientific concepts, which can be of great use when using the games as a didactic tool in class.

The game *Act on your consumption* presents another significant opportunity created by online games for interaction: convergence with other media and social networks over the Internet. This virtual world includes links to Facebook and Twitter, websites with additional information, the documentary "The Age of Stupidity", extracts from the press, among others.

The gameplay provides important communicative features (Table IV). For instance, our findings on game dynamics reveal that discovery and challenge, through decision-making and time pressure, are some of the most common strategies, portraying an explorer or creator type of player. In fact, decision-making under time pressure is considered a key skill to cope with climate change effects. Players must take various parameters into account in real time, prioritizing considerations and planning resources in a strategic way, by analyzing and evaluating information received critically on important considerations such as urban planning, energy, pollution or water management.

	Act on your consumption	***CO2 Alert***	***Climántica***	***Mission possible, save the planet***	***My Green Energy Planet***
Degree of interactivity	Medium-high	High	High	Medium-high	High
Dynamics and mechanics	Dynamics: discovery, narrative, emotions, expression	Dynamics: discovery, ability, challenge, narrative	Dynamics: challenge, ability, progression, discovery, sensation, narrative	Dynamics: discovery, challenge, narrative, fantasy	Dynamics: progression, discovery, challenge, status discovery, challenge
Player type	Explorer	Explorer	Creator	Explorer	Creator
Feedback system	Positive	Positive and negative	Positive and negative	Positive	Positive and negative
Reward system	No	Yes, status	Yes, virtual coins and eco-school	No	Yes, ecobono (virtual coins)

Table V. Findings on the gameplay dimension

When analyzing the feedback and reward system, we see the prevalence of a positive discourse. Rewards can act as motivators to take actions. Similarly, intangible rewards (extra points, virtual goods) are awarded by answering a quiz question correctly (as in *Misión Posible-Salvar el Planeta* or in *Actúa con tu Consumo*), making sustainable decisions under time pressure (*Climántica* or *My Green Planet*) or doing well in the puzzle games, whether it is by turning the street lights off quickly or by matching the cause/consequence images of climate change (*Alerta CO2*).

4.2.6. Discussion

In this paper we have proposed validated indicators to analyze the communicative elements of online climate change games, using a narratology and ludology perspective, and we have put them into practice, revealing their nature and some of their opportunities for climate change communication and education towards adolescents. Online climate change games, especially simulations, are shaping themselves as innovative strategies, by facing the communicative and educational challenges regarding climate change: causes are made visible, actions are portrayed as local, uncertainty is avoided, contextualized information is provided with positive and pro-action tone, and a critical thinking approach is encouraged.

Thanks to their immersive narrative and interactivity, among other analyzed features, games have capacity to convey to young people the problems that they will be facing in the future and enable them to experience these problems directly through the game, generally by adopting the roles of characters who have to be able to make sustainable decisions. It has been shown how narratives offer the player a range of possibilities at the same time, and it is the players themselves who decide in what order to establish them. The degree of interactivity, defined as the intervention in the content on the part of the player, as well as the very design of the game (personification, feedback, and rewards), play a very important part in the immersion process, to the extent of "negotiating" the players' own journey with them.

In relation to this, we consider personification in games as an opportunity for climate change communication and education, giving the option to the players to take on the roles of certain characters, playing an active role and being more than mere information consumers (López, Encabo & Jerez, 2011). Subjectivity strengthens the impression that the player "exists" in the world, and that I am "me" in the game. In the game *Misión Posible-Salvar el Planeta*, the players become ecological superheroes via avatars that fight against the uncontrolled emission of gases that cause climate change in the atmosphere. In the simulation games *Climántica* or *My Green Planet*, young people go deep into a virtual world and take on the roles of characters who have to manage an area and achieve an environmental, energetic and social balance – how? By analyzing and evaluating information received to make decisions on such important issues such as urban planning, energy, pollution or water management.

4.2.7. Conclusion

It can be concluded that the games analyzed seem to have incorporated the formula by Sheppard (2012) that was presented at the beginning of this paper: make it local, visual and connected. Although videogames are not the panacea, there is a need to pay more attention to these communication tools, especially to the simulations formats, which according to our analysis, seems to have a higher level of interactivity and immersive narrative. Despite our analysis of a sample of online climate change games produced in Spain is not by any means exhaustive, we do intend to contribute a preliminary approach to an emerging subject matter.

We would like to encourage academics and teachers to make use of the proposed checklist in this paper to analyze online climate change games in other countries and other languages to be able to make comparisons and to draw conclusions at a global

level. Future lines of investigation should also study in depth the narratives that generate the most interest among young people, the scientific rigour of the content, and the effectiveness of games in changing attitudes and behaviour. Furthermore, taking into account the fact that "serious games" of this type manage to set out complex concepts in a dynamic way in 15 minutes, another open line of investigation is how these tools can be applied in educational contexts.

4.2.8. References

Aguaded-Gómez, I. (2011). Niños y adolescentes: nuevas generaciones interactivas. *Comunicar 36*(XVIII), 7-8. doi: 10.3916/C36-2011-01-01

Aparici, R. & Silva, M. (2012). Pedagogía de la Interactividad. *Comunicar, 38*(XIX), 51-58. doi: 10.3916/C38-2012-02-05

Bienvenido *et al. (2013). El periodismo ante el cambio climático. Nuevas perspectivas y retos. Barcelona:* UOC.

Cooper, C. B. (2011). Media Literacy as a Key Strategy Towards Improving Public Acceptance of Climate Change Science. *BioScience, 61*(3), 231-237. doi: 10.1525/bio.2011.61.3.8

Cordero, E., Todd, A., & Abellera, D. (2008). Climate change education and the ecological footprint. *American Meteorological Society, 89*, 865-872. doi:10.1175/2007BAMS2432.1

De Vries, P.W. & Knowl, Erik (2011). EnerCities, a Serious Game to Stimulate Sustainability and Energy Conservation: Preliminary Results. *eLearning Papers* 25. Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1866206

Díaz-Nosty, B. (2013). Aproximación a la construcción interdisciplinar y de un Nuevo paradigma. Comunicación, cambio climático y crisis sistemática. *Razón y Palabra*, *84*. doi: 10.4185/RLCS-64-2009-808-99-119

European SchoolNet (2009). *How are digital games used in schools.* Brussels: European Schoolnet. Retrieved from http://games.eun.org/upload/gis-full_report_en.pdf

European Commission. (2011). *Climate Change Eurobarometer* (Report, Special Eurobarometer 372).

Retrieved from http://ec.europa.eu/public_opinion/archives/ebs/ebs_372_en.pdf

Escribano, F. (2012). Jóvenes y videojuegos. Estado del arte. *Revista de Estudios de Juventud, 98*, 9-23. Retrieved from http://ojs.lib.swin.edu.au/index.php/fdo

Fischoff, B. (2013). The Science of Science Communicatopn. In *Arthur M. Sackler Colloquium of the National Academy of Sciences*. Washington: National Academy of Sciences.

Garrido, J. M. (2013). ¿Por qué los estudiantes juegan con videojuegos de estrategia?: algunos principios para la enseñanza. *Revista Electrónica de Investigación Educativa, 15*(1), 62-74. Retrieved from http://redie.uabc.mx/vol15no1/contenido-garridojm.html

Gee, J.P. (2004). *Lo que nos enseñan los videojuegos sobre el aprendizaje y el alfabetismo.* Archidona: Aljibe.

Gónzalez-Gaudiano, E., & Meira-Cartea, P. (2009). Educación, comunicación y cambio climático. Resistencias para la acción social responsable. *Trayectorias, 11*(29). Retrieved from http://www.redalyc.org/articulo.oa?id=60712749003

Grifeu, A. (2010). *El documental interactivo. Evolución, caracterización y perspectivas de desarrollo*. Barcelona: Editorial UOC.

Grifeau, A. (2013). *El documental interactivo como nuevo género audiovisual. Estudio de la aparición del Nuevo género, aproximación a su definición y propuesta de taxonomía y de modelo de análisis a efectos de evaluación, diseño y producción* (Doctoral dissertation, Universidad Pompeu Fabra). Retrieved from http://www.doc.ubi.pt/14/teses_arnau_castells.pdf

Katsaliaki, K., & Mustafee, N. (2014). Edutainment for Sustainable Development: A survey of Games in the Field. *Simulation & Gaming, 1*(26). doi: 10.1177/1046878114552166

Lacasa P. (2011). *Los videojuegos: aprender en mundos reales y virtuales*. Madrid: Ediciones Morata

López-Valero, A., Encabo-Fernández, E. & Jerez-Martínez, I (2011). Competencia digital y literacidad: nuevos formatos narrativos en el videojuego «Dragon Age: Orígenes». *Comunicar, 36*(XVIII), 165-171. doi: 10.3916/C36-2011-03-08

Marcos, M. & Satorum, M. (2014). La narración del videojuego como lugar para el aprendizaje inmersivo. *Revista de Estudios de Juventud*, 98, 77-89. Retrieved from http://www.injuve.es/sites/default/files/2012/46/publicaciones/Revista98_6.pdf

Martí-Parreño, J., Méndez-Ibáñez, E., Giménez-Fita, E., & Queiro-Ameijeiras, C. (2015). El uso de la gamificación en la educación superior: propuesta de una ficha de análisis ludológico-narratológico. In M.A Ruiz Rosillo (Ed.), *XII Jornadas Internacionales de Innovación Universitaria Educar para transformar: Aprendizaje experiencial* (pp. 103-111). Madrid: Universidad Europea de Madrid.

McKenzie-Mohr, D. (2008). Fostering sustainable behavior: Beyond brochures. *International Journal of Sustainability Communication, 3*, 108-118. Retrieved from http://www.ijsc-online.org/en/details/mckenzie-mohr_03.php

Meira-Cartea, P.A. (2008). *Comunicar el cambio climático. Escenario social y líneas de actuación.* Madrid: Ministerio de Medio Ambiente y Medio Rural y Marino-Organismo Autónomo de Parques Nacionales. Retrieved from http://www.magrama.gob.es/es/ceneam/recursos/documentos/comunicar_cc_completo_tcm7-13513.pdf

Mitchell, A., & Savill-Smith, C. (2004). *The use of computer and video games for learning: A review of the literature*. London: Learning and Skills Development Agency.

Moser, S.C. (2010). Communicating Climate Change: History, Challenges, Process and Future Directions. *WIREs Climate Change, 1*, 31-53. doi: 10.1002/wcc.011

Moser, S.C., & Dilling, L. (2011). Communicating Climate Change: Closing the Science-Action Gap. In J.S. Dryzek, R.B. Norgaard, & D. Schlosberg (Eds.), *Oxford Handbook of Climate Change and Society*. Oxford: Oxford University Press.

Pérez-Latorre, O. (2010). *Análisis de la significación del videojuego. Fundamentos teóricos del juego, el mundo narrativo y la enunciación interactiva como perspetivas de estudio del discurso* (Doctoral dissertation, Universidad Pompeu Fabra). Retrieved from http://www.tesisenred.net/bitstream/handle/10803/7273/topl.pdf?sequence=1

Piñuel Raigada, J.L. (2013). El discurso hegemónico de los Media sobre el Cambio Climático (Riesgo, Incertidumbre y Conflicto) y estrategias de intervención. In VV. AA (Eds.), *Medios de Comunicación y Cambio Climático* (pp.13-33). Sevilla: APIA,

Prensky, M. (2001). Digital natives, digital immigrants. *On The Horizon*, *9*(5), 1-6. doi:10748120110424816

Poole, S. (2006). *Unspeak: words are weapons: the language of everyday deception*. London: Little Brown.

Reckien, D., & Eisenack K. (2013). Climate Change Gaming on Board and Screen: A review. *Simulation and Gaming, 44*(2-3), 253-271. doi:10.1177/1046878113480867

Scapolo, F. & Miles, I. (2006). Eliciting expert´s knowledge: a comparison of two methods. *Technological Forecasting and Social Change, 3,* 670-704.

Schafer, M. (2012). Online communication on climate change and climate politics: literature review. *WIREs Climate Change, 3*(6), 527–543. doi:10.1002/wcc.191

Science for Nature and People (SNAP). *Gaming the Future: Designing video games that change the way people think about climate change. Retrieved February 1,* 2015 from http://goo.gl/UnNnj7

Sheppard, S.R.J. (2012). *Visualizing climate change: A guide to visual communicatin of climate change and developing local solutions*. Abingdon, Oxon: Routledge.

Sinde Martínez, J., Medrano Samaniego, C., Martínez de Morentin, J.I. (2015). Transmisión de valores en adolescentes: un análisis con videojuegos. *Revista Latina de Comunicación Social*, *70*, 230-251.

Tejeiro, R. & Pelegrina, M. (2003). *Los videojuegos: qué son y cómo nos afectan*. Barcelona: Ariel.

Werbach, K. & Hunter, D. (2012) *The gamification toolkit. Dynamics, mechanics and components for the win.* Pennsylvania: Wharton Digital Press.

4.3. Evaluación de juegos online para la enseñanza y aprendizaje del cambio climático

Article 3: Ouariachi, T., Olvera-Lobo, M.D y Gutiérrez-Pérez, J. (2017). "Evaluación de juegos online para la enseñanza y aprendizaje del cambio climático". *Enseñanza de las Ciencias: revista de investigación y experiencias didácticas*, *22* (73), 193-214. DOI: 10.5565/rev/ensciencias.2088

Los juegos online han sido propuestos como una herramienta de comunicación y educación prometedora. Teniendo en cuenta que el cambio climático es una de las principales amenazas a las que se enfrentan los adolescentes en su futuro, el presente trabajo tiene como objetivo principal la evaluación de los elementos comunicativos y educativos de una serie de juegos online sobre cambio climático producidos en España, haciendo uso de unos criterios validados por un panel de expertos con el método Delphi. Los resultados de este estudio exploratorio revelan algunas de las oportunidades que ofrecen estas herramientas, tales como el encuadre alternativo de los mensajes o el desarrollo de distintas competencias y habilidades, pero también sus limitaciones, como la falta de instituciones científicas en la producción o de posibilidades para estudiantes con diversidad funcional.

4.3.1. Introducción

El compromiso de los jóvenes en la lucha contra el cambio climático resulta primordial para transformar el mundo. Sin embargo, tal y como revelan las últimas encuestas sobre percepción del cambio climático en España, el conocimiento del problema es aún limitado y se observa una notable ausencia de compromiso para adoptar medidas de mitigación y de adaptación al cambio climático (Fundación Mapfre, 2013).

Diversos estudios han revelado que la manera en la que se ha comunicado y educado en cambio climático no ha sido efectiva hasta ahora y que, por lo tanto, existe una necesidad urgente de buscar nuevas estrategias para fomentar la concienciación y la acción social. Tomando a los jóvenes como sector poblacional objetivo, sería lógico proponer estrategias que se correspondan con el nuevo paradigma comunicativo de los llamados "nativos digitales" (Prensky, 2001), quienes han crecido en un mundo rodeado de ordenadores, Internet o videojuegos (Tapscott, 2009). En este sentido, los videojuegos sobre cambio climático se han convertido en un campo de estudio emergente al considerarse un método innovador para promover la enseñanza y aprendizaje de las ciencias. A juzgar por relevantes informes como el *Horizon Report* en Educación Superior, los videojuegos alcanzarán su máximo apogeo en 2020 (Johnson et al., 2011).

Autores como Katsaliaki & Mustafee (2014), Reckien & Eisenack (2013), y Wu & Lee (2015) han llevado a cabo recientemente evaluaciones de videojuegos sobre cambio climático. Sin embargo, en primer lugar, estos estudios no contemplan una evaluación holística de elementos comunicativos (desde una perspectiva narratológica y ludológica) y educativos; y en segundo lugar, prestan atención principalmente a los videojuegos de habla inglesa, mientras que los videojuegos en español y producidos en países no anglosajones han recibido escasa consideración a pesar de su proliferación. España sin ir más lejos es cuarta potencia en Europa y novena en el mundo el sector de los videojuegos, y en los cinco últimos años ha experimentado un crecimiento medio anual del 47% en la producción de *serious games*, incluyendo temas como el cambio climático (DEV, 2015).

Bajo estas premisas y considerando el cambio climático como una de los principales retos a los que se enfrentan los jóvenes, la investigación llevada a cabo se plantea como objetivo principal la evaluación cualitativa de los elementos comunicativos y educativos de una serie de juegos online sobre cambio climático producidos en España, haciendo uso de unos criterios validados por un panel de expertos.

Asimismo, se han establecido como objetivos secundarios: *a)* explorar la naturaleza y características de algunos de estos videojuegos, facilitando a los docentes de educación secundaria la elección de entre tantos recursos educativos disponibles en la Red como instrumentos de trabajo en el aula; y *b)* abordar algunas de las oportunidades y limitaciones que ofrecen estas herramientas para la comunicación y educación en cambio climático.

En este trabajo, en primer lugar, se presenta el marco teórico donde se aborda la relación entre videojuegos y aprendizaje, así como los desafíos de la comunicación y educación sobre cambio climático. Posteriormente, se detalla la metodología utilizada para compilar, seleccionar y evaluar los juegos. Tras presentar los resultados de la evaluación de los juegos, se plantean, en la sección dedicada a la discusión de los resultados y a las conclusiones del estudio, las implicaciones de esta evaluación.

4.3.2. Desafíos en la comunicación y educación sobre cambio climático

Muchos de los esfuerzos en la comunicación y educación sobre el cambio climático para promover concienciación y acción pro-ambiental con el objetivo de reducir emisiones de gases de efecto invernadero, han fracasado y no necesariamente por la poca disponibilidad de información (Niesbet & Scheufele, 2009). Algunos de los desafíos que caracterizan el paradigma comunicativo clásico en relación con el cambio climático tienen que ver con la responsabilidad de los medios de comunicación en la denominada "lógica de la distribución" y la transmisión unidireccional de los mensajes (Aparici & Silva, 2012), así como con la propia producción de contenido informativo sobre este tema, con escasa contextualización y elevado tono negativo-alarmista (León, 2013; Cooper, 2011; Moser, 2010; Shafer, 2012), y en parte con la propia naturaleza del cambio climático, por su complejidad desde el punto de vista científico (Meira, 2008). De igual modo, desde la segunda mitad del siglo XX se viene criticando el modelo pedagógico vigente debido a esta unidireccionalidad de la información que divide al emisor y receptor, que pasivamente consume esa información (Aparici & Silva, 2012).

Parte de la solución a tales desafíos pasaría por adoptar el modelo de *public engagement in science*, que implica entre otros aspectos una comunicación más participativa y más en sintonía con el universo comunicacional de los nativos digitales, por el cual el público deja de ser mero receptor pasivo del mensaje para adquirir y construir conocimiento de manera activa y en un contexto significativo (Cooper, 2011). Este modelo enfatiza la importancia de promover confianza para motivar y empoderar a los ciudadanos a la hora de tomar decisiones sobre la ciencia o el medio ambiente, y para construir esa confianza, se defiende un aprendizaje activo y mutuo entre ciudadanos y científicos, y la coproducción de conocimientos (Groffman et al., 2010).

Además, se hace necesario a) enmarcar el mensaje de manera distinta, aportando en la información mayor contextualización, soluciones y actuaciones a nivel individual, proximidad geográfica, tono positivo, y discursos que, más allá de lo político o lo

medioambiental, aborden temáticas transversales como la salud, el consumo o la justicia (León, 2013; Cooper, 2011; Maibach et al., 2010; Meira, 2008; Piñuel-Raigada & Teso-Alonso, 2012); y b) añadir una perspectiva más crítica a la educación de las ciencias en general, y medioambiental en particular, abriendo espacios de reflexión y debate sobre posibles alternativas de cambio (Cooper, 2011; Michael & Savill-Smith, 2004; Nisbet & Scheufele, 2009). Por lo tanto, el diseño y desarrollo de proyectos educativos de cambio climático que incluya concienciación, conocimientos, valores y oportunidades para la participación pueden atraer un aprendizaje más profundo.

4.3.3. Videojuegos y aprendizaje

Los videojuegos son juegos electrónicos que se sirven de la tecnología informática y permiten la interacción a tiempo real del jugador con la máquina, y en el que la acción se desarrolla sobre un soporte visual (Tejeiro & Pelegrina, 2003). Los juegos online por su parte serían una modalidad de videojuego con la particularidad de que se accede a través de un navegador web y están disponibles en Internet. El usuario de videojuegos pretende divertirse o entretenerse, pero al mismo tiempo está desarrollando capacidades y conocimientos, especialmente cuando la temática del juego es seria, como es el caso del cambio climático. A este tipo de videojuegos que van más allá de la diversión y apuntan a transmitir ideas, valores y en ocasiones a persuadir a los jugadores se les ha denominado también *serious games* (Frasca, 2007). Por lo tanto, al hablar de "juegos online sobre cambio climático" nos centramos en juegos sobre temática específica en cambio climático con fines comunicativos y educativos, independientemente de integrar diversión y entretenimiento, y que están disponibles en Internet.

Bajo el paradigma del "aprendizaje basado en juegos digitales" (*digital game-based learning* en inglés), autores como Gee (2004) o Prensky (2001) proponen un modelo innovador basado en la utilización de los videojuegos como herramientas de apoyo al aprendizaje, ofreciendo a profesores y alumnos una experiencia educativa diferente y aplicada a asignaturas tales como las ciencias. Gee (2008) argumenta que los buenos videojuegos reflejan una descripción formal de cómo los científicos abordan los problemas: construyen hipótesis, diseñan un experimento para establecer la hipótesis, evalúan los resultados y refinan la hipótesis. Prensky (2001) examina cuestiones estéticas, cognitivas y pedagógicas alrededor de los juegos y aporta decenas de casos de estudio. En España, Lacasa (2011) presenta diversas situaciones reales en las que se han llevado a cabo actividades dentro del aula dedicadas al aprendizaje a través de distintos videojuegos.

Como adelantábamos en la introducción, a pesar de que las iniciativas y las evaluaciones de juegos sobre cambio climático están emergiendo, la mayoría de los criterios propuestos para estas evaluaciones prestan poca atención a los elementos comunicativos y educativos en su conjunto y a las particularidades del formato online. Desde la perspectiva comunicativa, los investigadores en videojuegos se han divido entre aquellos que defiende que los juegos se analicen desde una perspectiva narratologista, entendiendo los juegos como medios para generar historias (ej.: Murray, 1999), o una perspectiva ludologista, prestando más atención al diseño del juego y sus reglas, y de cómo éstas transmiten también significados (ej.: Juul, 2005). Nuestra perspectiva teórica a la hora de evaluar la muestra de juegos está inspirada en el "Modelo de análisis de la significación del videojuego" de Pérez-Latorre (2010), que integra ambas perspectivas de análisis.

Por otro lado, en educación primaria, los juegos vienen siendo elementos básicos de las actividades escolares, sin embargo en educación secundaria este enfoque no se empezó a considerar hasta recientemente, con el boom de los dispositivos tecnológicos. Las características de los "nativos digitales" empezaron a ser reconocidas por la comunidad docente, que empezó a entender que los juegos online podrían jugar un papel importante en la educación de los adolescentes, quienes dedican horas jugando y navegando por Internet (Ruiz-Dávila et al, 2008).

4.3.4. Metodología

En este estudio de carácter cualitativo, exploratorio e interdisciplinar, se compilan, seleccionan y evalúan una muestra de juegos online sobre cambio climático haciendo uso de una *checklist* con criterios de evaluación validados por un panel de expertos. Siguiendo una metodología cualitativa, a continuación detallamos los pasos e instrumentos:

Establecimiento de una checklist con indicadores de evaluación validados

Para poder evaluar los juegos, se decidió desarrollar una *checklist* con una serie de criterios de evaluación pertinentes para el tema del cambio climático. Con el fin de validar estos criterios, se hizo uso del método Delphi, un proceso estructurado e interactivo que colecciona opiniones de expertos que alcancen acuerdo y consenso (Scapolo & Miles, 2006). Contamos con un panel internacional de 13 expertos en el ámbito del cambio climático, comunicación científica, periodismo, educación ambiental y videojuegos, quienes fueron elegidos por su experiencia teórica y práctica, su motivación para participar en el estudio y la facilidad de ser contactados. Se mantuvo comunicación por correo electrónico y el proceso fue interactivo y anónimo en todo momento.

El proceso constó de tres rondas. En la primera ronda, se les solicitó que evaluaran la relevancia y utilidad de unas dimensiones de evaluación (categorías de evaluación que sirven como guía para organizar los criterios) y criterios de evaluación preliminares (indicadores, elementos a considerar cuando se evalúan los juegos), identificados a raíz de una revisión bibliográfica (Blooom, 1956; European SchoolNet, 2009; Katsaliaki & Mustafee, 2014; Kim, 2012; Lacasa 2011; León et al., 2013; Liarakou et al., 2012; Liu & Ding, 2009; Martí-Parreño et al., 2014; Meira-Cartea, 2008; Mitgutsch & Alvarado, 2012; Moser, 2010; Pérez-Latorre, 2010; Piñuel-Raigada et al., 2009; Reckien & Eisenack, 2013; Werbach & Hunter, 2012). Los criterios fueron preseleccionados por su potencial en ofrecer información relevante y útil sobre aspectos tanto educativos como comunicativos, desde la narratología y la ludología como se indicó en el marco teórico.

En la segunda ronda de consultas se arbitró una valoración de la relevancia y utilidad de los criterios de evaluación en términos ordinales (alta, media, baja) a través de un cuestionario online, con el fin de calibrar discrepancias y conseguir un primer consenso en la selección inicial de las variables de análisis. La selección de criterios en esta etapa se basó en la obtención de un consenso del 90% (porcentaje acumulado entre alta y media). En la tercera y última fase, se pidió a los expertos un posicionamiento desde sus respectivas áreas de experiencia ante aquellos criterios que no superaron la segunda fase, con el fin de calibrar consenso y confirmar la selección final de criterios. Esta valoración se planteó a través de un cuestionario con preguntas cerradas dicotómicas, en

la que los expertos debían responder si estaban de acuerdo o no con que los criterios que no fueron aprobados en la segunda ronda quedaran fuera de la selección final. Una vez alcanzado un consenso y estabilidad en los resultados, se concluyó el proceso.
A continuación se presentan las dimensiones y los criterios de evaluación:

Dimensiones	**Descripción**	**Criterios de evaluación**
Identificación	Rasgos que ayudan a identificar y localizar al juego	• Título del juego • URL: *link a la web* • Emplazamiento en la web: *la URL puede estar emplazada en una página web independiente, en una sección de la página web del productor/autor o en una sección de otra página web. Este criterio permite valorar su visibilidad online* • Disponibilidad de aplicación para móviles: *el juego online puede disponer de una versión para móviles a través de una aplicación* • Gratuidad: *si el juego es gratuito o de pago* • Idioma: *lengua o lenguas que se emplean en el juego* • Tipo de creador*: nombre y tipo de instrucción detrás de la creación del juego* • Objetivo comunicativo: *intenciones comunicativas y objetivos* • Descripción breve: *resumen según género objetivos e historia*
Narrativa	Análisis de las estructuras narrativas, estudio del juego como narración y como contexto en el que se establecen las condiciones para producir el mensaje	• Peso narrativo: *elementos narrativos pueden adquirir importancia o ser irrelevantes* • Existencia de un narrador: *mediador que relata hechos* • Historia global: *descripción del relato del juego en su conjunto, basado en la sucesión lógica o causal de hechos por un tiempo determinado* • Representación y rol del personaje: *características y cualidades del personaje/ avatar* • Representación del entorno: *el mundo en el que el personaje/jugador se desenvuelve* • Dimensión/espacio/escala: *contexto general y escala de los escenarios* • Dimensión/temporalidad: *periodo que abarca la historia*
Contenidos	Análisis del contenido del juego y los mensajes que se transmiten en torno al cambio climático, el cual puede revelarse a través de textos, audios e imágenes	• Término empleado: *terminología más empleada para describir el fenómeno "cambio climático", "calentamiento global"* • Presencia de falsos conceptos- errores: *existencia de conceptos e ideas erróneas en relación al fenómeno del cambio climático* • Uso explícito de conceptos científicos: *definición de conceptos en relación al fenómeno estudiado* • Uso explicito de fuentes de información: *cita de fuentes y origen de los datos* • Convergencia con otros medios y redes sociales: *enlaces a redes sociales* • Marco del mensaje: *temas, causas/consecuencias y tono del mensaje* • Imágenes
Jugabilidad	Análisis de las estructuras lúdicas del juego; estudio del juego como juego, en función de mecánicas, y de cómo su diseño produce significado	• Nº jugadores • Uso: *individual vs. colectivo* • Tipo de jugador: *el juego puede encajar en distintos perfiles de jugador* • Duración: *se refiere al tiempo empleado por nivel-misión o durante todo el juego* • Grado de interactividad: *grado de intervención, modificación y elección sobre el contenido por parte del usuario* • Misión del juego: *acciones esenciales para ganar el juego* • Dinámicas: *estructura, reglas y elementos básicos del diseño* • Sistema de recompensas: *este criterio evalúa los incentivos a las acciones* • Sistema de feedback: *comentarios a través del texto, audio o audiovisual que recibe el jugador ante determinadas acciones* • Disponibilidad de instrucciones de juego: *guía interna o en pdf que nos indica paso por paso las acciones que debemos llevar a cabo para avanzar en un juego* • Posibilidad de guardar la partida*: posibilidad de guardar la partida y reiniciarla cuando se desee*

Didáctica	Análisis del juego como recurso didáctico; estudio de los elementos pedagógicos y educativos	• Competencias: *conocimientos y actitudes que alcanza el estudiante* • Habilidades: *operaciones mentales que alcanza el estudiante* • Condiciones de resolución de problemas: *tipo de razonamiento para resolver problemas* • Necesidad de conocimientos previos: *esta necesidad se verá influenciada por el nivel de dificultad del juego* • Curva de aprendizaje: *nivel de dificultad en el aprendizaje* • Posibilidad de trabajo en grupo: *se refiere a la posibilidad de formar grupo de estudiantes en torno a los ordenadores* • Accesibilidad: *disponibilidad del juego para estudiantes con diversidad funcional* • Interdisciplinariedad: *combinación de dos o más disciplinas académicas* • Acompañamiento de guía didáctica: *documento o enlace a información destinada a los docentes con consejos y sugerencias para implementarlo en el aula* • Posibilidad de evaluación del docente: *el docente puede acceder a historial de acciones, registro de intervenciones, etc.*

Tabla 1. Dimensiones y criterios de evaluación

Recopilación, selección y evaluación de juegos

Para identificar y recopilar juegos se realizó una búsqueda web en el periodo comprendido entre mayo-julio 2015 en el portal de búsqueda Google, usando la siguiente ecuación: ("videojuego" O "juego online" O "juego educativo" O "eco-juego") Y ("cambio climático" O "calentamiento global" O "sostenibilidad" O "medioambiente"), en español. Se prestó especial atención a directorios de ONGs e instituciones gubernamentales, así como blogs y sitios web especializadas en educación 2.0 y videojuegos.

Con el fin de seleccionar los juegos, los investigadores interactuaron con los juegos para confirmar que respondían a los siguientes criterios de selección:

- Juegos producidos en España y en español y/o idiomas cooficiales en España, lo cual permite dar visibilidad a juegos producidos en un país y en una lengua distinta a la anglosajona.
- Juegos albergados en una plataforma web y jugados a través de Internet; nuestro objeto de estudio se centra en juegos online por su popularidad entre los jóvenes adolescentes.
- Juegos gratuitos, ya que posibilita un mayor uso y acceso ante la posibilidad de escasez de recursos económicos en los centros educativos destinados a estos fines.
- Juegos que persiguen objetivos comunicativos y educativos, centrados exclusivamente en temática de cambio climático
- Juegos destinados a un público adolescente mayor de 12 años, la audiencia en la que se centra este estudio ante la necesidad de segmentar los públicos en función de sus edades y diferentes procesos cognitivos.

Se excluyeron aquellos juegos sólo disponibles mediante descarga o aplicación móvil, cuyos enlaces web ya no están disponibles, de producción extranjera, y aquellos destinados a público infantil. Los juegos escogidos, además de responder a nuestros criterios de selección, aparecen en los primeros puestos de los motores de búsqueda en Internet, en los principales blogs especializados en enseñanza de las ciencias medioambientales y en materiales educativos recomendados por el Centro Nacional de

Educación Ambiental y otras instituciones gubernamentales. También son mencionados en conversaciones entre la comunidad de usuarios de videojuegos. Estos juegos son:

- *Actúa con tu consumo:* distribuido en más de 150 centros de la Red de Centros Educativos en Acción de Greenpeace; material pensado para su uso de forma transversal en clases con actividades online (enfrente de la pantalla) -offline (fuera de la pantalla).
- *Alerta CO2:* mil unidades distribuidas en centros educativos y puntos de información ambiental; ganador del 12º premio Civismo en los Medios de Comunicación en la modalidad de página web de la Generalitat de Catalunya (2007).
- *Climántica:* enmarcado dentro del proyecto de educación ambiental de la Xunta de Galicia con el mismo nombre, recomendado por el Alto Comisionado de las Naciones Unidas para el Cambio Climático.
- *Misión posible, Salvar el planeta:* forma parta de la saga de juegos de Educación Ambiental y Sostenibilidad que pretende favorecer la participación y la reflexión crítica en la resolución de problemas ambientales.
- *My Green Planet:* forma parte de una de las mayores campañas de sensibilización para luchar contra el cambio climático: La Hora del Planeta.

Para hacer una evaluación cualitativa de los elementos comunicativos y educativos de los juegos se usó la *checklist* de criterios validados. Dos investigadores participaron en la codificación del material haciendo uso de las dimensiones y de los criterios recogidos en la Tabla 1, teniendo en cuenta niveles, misiones y/o episodios como unidades de análisis, lo que sería equivalente a las escenas en las películas o los *strip-frames* en los cómics. Ambos investigadores analizaron toda la muestra y contrastaron los puntos de vista para complementar las respectivas evaluaciones.

4.3.5. Resultados

Haciendo uso de la *checklist* que se muestra en la Tabla 1, se presenta a continuación una evaluación cualitativa de la muestra de juegos seleccionados, a la vez que se evidencia el uso y utilidad de los criterios de evaluación validados.

Identificación

En primer lugar, nuestra evaluación muestra la prevalencia de las ONGs entre los principales creadores de juegos. También es interesante observar la implicación de los gobiernos autónomos en la financiación de juegos y la inclusión de idiomas como el catalán o el gallego.

En relación a los objetivos comunicativos, la Tabla 2 muestra que la mayoría de estos juegos pretenden desarrollar familiaridad con el tema, además de la concienciación sobre causas y consecuencias, la promoción de cambio de actitudes, y por último, el fomento de desarrollo de ideas y soluciones a través de creatividad.

Nombre del juego	URL y emplazamiento en la web	App	Idioma	Creador	Objetivo comunicativo	Descripción breve
Actúa con tu consumo	http://consumo.greenpeace.es/ (web independiente)	No	Español	Greenpeace España	Desarrollar familiaridad con el tema; concienciación sobre causas-consecuencias; promover cambio de actitudes; fomentar reflexión y desarrollo de ideas	Diversos mini-juegos, quiz y actividades que promueven consumo crítico y responsable, haciendo al jugador reflexionar sobre el impacto de sus acciones en el medioambiente y el cambio climático
Alerta CO2	http://www.accionatura.org/jocAlertaCO2/index.html (sección de la web institucional)	No	Español y Catalán	Acción Natura / Con financiado de la Generalitat de Catalunya	Desarrollar familiaridad con el tema; concienciación sobre causas-consecuencias; promover cambio de actitudes	El jugador encuentra diversos mini-juegos en una ciudad virtual que se contamina aceleradamente según las decisiones que se tomen; el objetivo es crear concienciación sobre las emisiones de CO2
Climántica	http://xogo.climantica.org/?locale=es (web independiente)	No	Español, Gallego e Inglés	Xunta de Galicia	Desarrollar familiaridad con el tema; concienciación sobre causas-consecuencias; promover cambio de actitudes; fomentar reflexión y desarrollo de ideas	Simulación, que incluye mini-juegos, en la que el jugador crear y gestiona un territorio sostenible, planificado acciones de manera estratégica y siendo consciente de las causas y consecuencias del cambio climático
Misión posible, salvar el planeta	http://www.cruzroja.es/juego_cambio_climatico/ (sección de la web institucional)	No	Español	Cruz Roja Española / Con financiación del Ministerio de Medioambiente	Desarrollar familiaridad con el tema; concienciación sobre causas-consecuencias; promover cambio de actitudes	Jugadores se convierten el superhéroes ecológicos que luchan contra la emisión descontrolada de gases de efecto invernadero a la atmósfera, superando diversos mini-juegos y quiz
My Green Energy Planet	http://www.wwf-spainsites.com/mygreenenergyplanet/	No	Español	Fundación AXA + WWF España	Desarrollar familiaridad con el tema; concienciación sobre causas-consecuencias; promover cambio de actitudes	Simulación creada para concienciar y cambiar modelo energético para mitigar los efectos del cambio climático, para lo que el jugador tendrá que convertir la ciudad en un territorio sostenible

Tabla 2. Resultados de la dimensión identificación

Narrativa

En segundo lugar, de esta evaluación se desprende una diversidad de historias, representación de personajes y entornos (Tabla 3). Destacan los roles de jóvenes ciudadanos que tienen que reducir las emisiones de CO2 en su día a día y en escenarios tan cercanos como una habitación o en su instituto; así como alcaldes o gestores de territorios sostenibles que tienen que tomar decisiones en ámbitos tan diversos como la producción de energía, la construcción de alojamientos o los avisos meteorológicos. Sólo uno de los juegos de nuestra muestra opta por la fantasía, convirtiendo a los jugadores en superhéroes con súper poderes para luchar contra el cambio climático. En casi todos estos juegos se hace una conexión entre el presente y el futuro, permitiendo a los jugadores ser conscientes del impacto de sus decisiones y permitiéndoles experimentar de forma directa a través del juego.

	Actúa con tu consumo	***Alerta CO2***	***Climántica***	***Misión posible, salvar el planeta***	***My Green Energy Planet***
Peso narrativo	Alto	Alto	Alto	Alto	Alto
Existencia de narrador	Si, Eva	No	El pingüino CLIMI	Si	No
Historia global	Eva es una joven activista, consciente de su poder como consumidora y su impacto sobre el cambio climático. En diferentes escenarios de su ciudad, analiza problemas, busca soluciones y se une a movimientos sociales	Exceso en las emisiones de CO2 han calentado la atmósfera. EL jugador debe buscar soluciones a las actividades diarias y parar el calentamiento global	Muchas personas se están mudando a un Nuevo territorio debido a la contaminación de sus lugares de origen. Durante 20 años, el alcalde debe crear un territorio sostenible para la nueva población que va llegando	La humanidad está en un momento decisivo para su supervivencia, las emisiones de efecto invernadero son una amenaza. Los superhéroes tienen que luchar contra l cambio climático	En un mundo virtual el alcalde debe tomar acciones correctas para mantener el equilibro medioambiental, energético y social
Representación y rol del personaje	Eva es una joven activista de Greenpeace, comprometida con el medioambiente y la sociedad. Irónica y crítica	Joven ciudadano	Alcalde	Superhéroes, 3 masculinos y 3 femeninos con súper poderes como habilidad de convicción	Alcalde
Representación del entorno	Ciudad contaminada y llena de tráfico, con protestas en la calle. Existen espacios para la movilización ciudadana	Metrópolis es una ciudad con distintas Fuentes de contaminación, parece desértica. El humo de las industrias es muy visible	Territorio de interior cruzado por un valle; territorio cercano a la costa; territorio en la costa con zonas de arena y hierba	Planeta con un alto nivel de peligro causado por el cambio climático	Ciudad muy desarrollada con aeropuerto, puerto, centros comerciales, etc. Territorio afectado a menudo por fuertes vientos y lluvias
Dimensión/ espacio/escala	Ficticio/local	Ficticio/local	Ficticio/local	Real/ global: Andes, Desierto Africano, Mar del Caribe	Ficticio/local
Dimensión/ temporalidad	Presente	Presente-futuro	Presente-futuro	Presente-futuro	Presente-futuro

Tabla 3. Resultados de la dimensión narrativa

Contenidos

Atendiendo a la dimensión contenidos (Tabla 4), la evaluación muestra una preferencia por el término "cambio climático" sobre "calentamiento global". Aspectos positivos a tener en cuenta son la inexistencia de conceptos erróneos; la inclusión explícita de conceptos científicos complejos explicados de manera sencilla; y la convergencia con redes sociales, otras páginas web y materiales audiovisuales, facilitando el acceso a otras fuentes de información y profundizando en la competencia digital de los jugadores. Un aspecto menos positivo es que juegos como *Misión posible, salvar el planeta* combinan el tema del cambio climático con otros temas y problemáticas medioambientales, lo que puede dar lugar a confusión entre los jugadores a la hora de diferenciar fenómenos o establecer relaciones causales. En la Figura 1 por ejemplo se puede observar cómo se relaciona de forma arbitraria dos problemáticas distintas, el cambio climático y la contaminación del agua, sin ampliar el contexto (causas y consecuencias) que distingue a cada uno de estos fenómenos. El jugador, tras encontrar una palabra o frase escondida, no recibe información o interactúa con estos conceptos presentados.

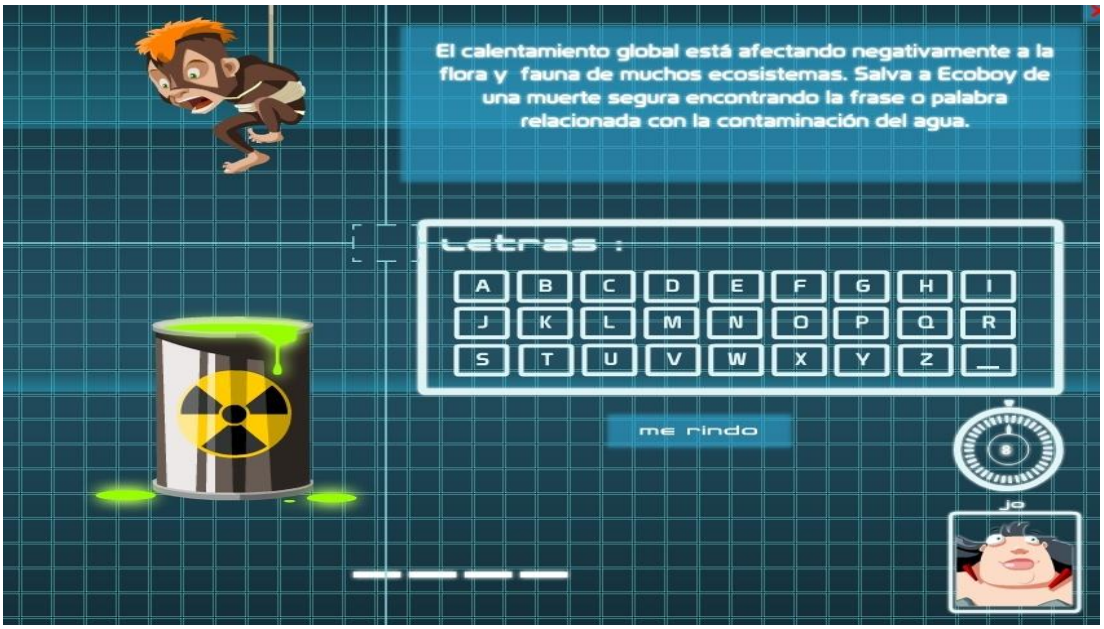


Figura 1. Relación de dos problemáticas medioambientales distintas en *Misión posible, salvar el planeta*

Algunas de las acciones que se promueven en estos juegos son iniciar campañas de movilización y concienciación ciudadana, consumir menos carne, adquirir productos de tiendas locales, reciclar, reducir y reusar productos, ahorrar energía o apostar por energías renovables (Figura 2). Esto muestra que los juegos no sólo reflejan los problemas sino también las soluciones, tanto a nivel individual como colectivo.

Figura 2. Acción "desmantelar central nuclear" en *My Green Planet*

El tono alarmista de algunos mensajes se acompañan por tonos proactivos y esperanzadores. Además, algunos de estos juegos enmarcan el mensaje en la solidaridad y la justicia. Igualmente, en estos juegos no cabe duda de la influencia de las actividades

humanas en la causa del cambio climático debido a la incontrolada emisión de gases de efecto invernadero a la atmósfera, especialmente el CO2 (Figura 3). Algunas de las consecuencias para el medioambiente y la sociedad se hacen visibles de manera clara y visual en estos juegos.

Figura 3. Explicación de las causas en Alerta CO2

	Actúa con tu consumo	***Alerta CO2***	***Climántica***	***Misión posible, salvar el planeta***	***My Green Energy Planet***
Término empleado	Cambio climático	Calentamiento global	Cambio climático	Cambio climático	Cambio climático
Presencia de falsos conceptos-errores	No	No	No	No	No
Uso explícito de conceptos científicos	Cambio climático, sello FSC, alimentos transgénicos	Calentamiento global, efecto invernadero	Agricultura intensiva, efecto invernadero, energías renovables, energías fósiles	No	Biomasa, energía geotérmica, compostaje, central hidroeléctrica, purificadora, energía geotérmica (más de 500 definiciones)
Uso explicito de fuentes de información	Informes del IPCC, documental "La era de la estupidez", páginas web	No	No	No	No
Convergencia con otros medios y redes sociales	Facebook y Twitter	Facebook y Twitter	No	No	Facebook y Twitter
Marco del mensaje	Temas: consumo, participación ciudadana, gestión de residuos, transporte Causas: altas emisiones de GEI Consecuencias: medioambiente, salud y sociedad Tono del mensaje: pro-acción, protesta, cercanía	Temas: energía, reducción de desastres, gestión de residuos, transporte y movilidad Causas: alta emisión de CO2 Consecuencias: fenómenos meteorológicos extremos, subida del nivel del mar,	Temas: planificación urbana, energía, agua, gestión de residuos, adaptación Causas: altas emisiones de GEI Consecuencias: aumento de temperatura, fenómenos meteorológicos extremos, amenaza	Temas: biodiversidad, transporte y movilidad Causas: altas emisiones de GEI Consecuencias: amenaza a ecosistemas, fenómenos meteorológicos extremos, desertificación	Temas: Planificación urbana, energía, agua, gestión de residuos, transporte, adaptación Causas: modelo energético Consecuencias: aumento de temperatura, desertificación, consecuencias

		derretimiento glacial Tono del mensaje: alarmista, ético, pro-acción, informativo	al ecosistema Tono del mensaje: pro-acción, ético, alarmista, protesta	Tono del mensaje: alarmista, pro-acción, informativo, esperanzador, humor	económicas Tono del mensaje: pro-acción, ético, alarmista e informativo

Tabla 4. Resultados de la dimensión contenidos

Jugabilidad

En la dimensión jugabilidad (Tabla 5), es de destacar la prevalencia del descubrimiento y desafío en las dinámicas de los juegos, a través de la toma decisiones y presión de tiempo (Figura 1). Las acciones que se contemplan vienen acompañadas de *feedback* (evaluación de las actuaciones y su impacto) y elogios (comentarios positivos) a través del discurso de los propios narradores de la historia o con notas explicativas que aparecen en pantalla (Figura 4).

Figura 4. Elogio tras una buena decisión en *Climántica*

Igualmente, se otorgan recompensas intangibles (puntos extra, bienes virtuales) al responder correctamente a las preguntas de los tests o quiz (como en *Misión Posible, Salvar el Planeta* o en *Actúa con tu Consumo*), tomar decisiones sostenibles bajo la presión del tiempo y manteniendo la satisfacción de la población (*Climántica* o *My Green Planet*) o afinando bien en los juegos de habilidad, ya sea apagando rápidamente farolas o uniendo imágenes causa-consecuencia del cambio climático (*Alerta CO2*).

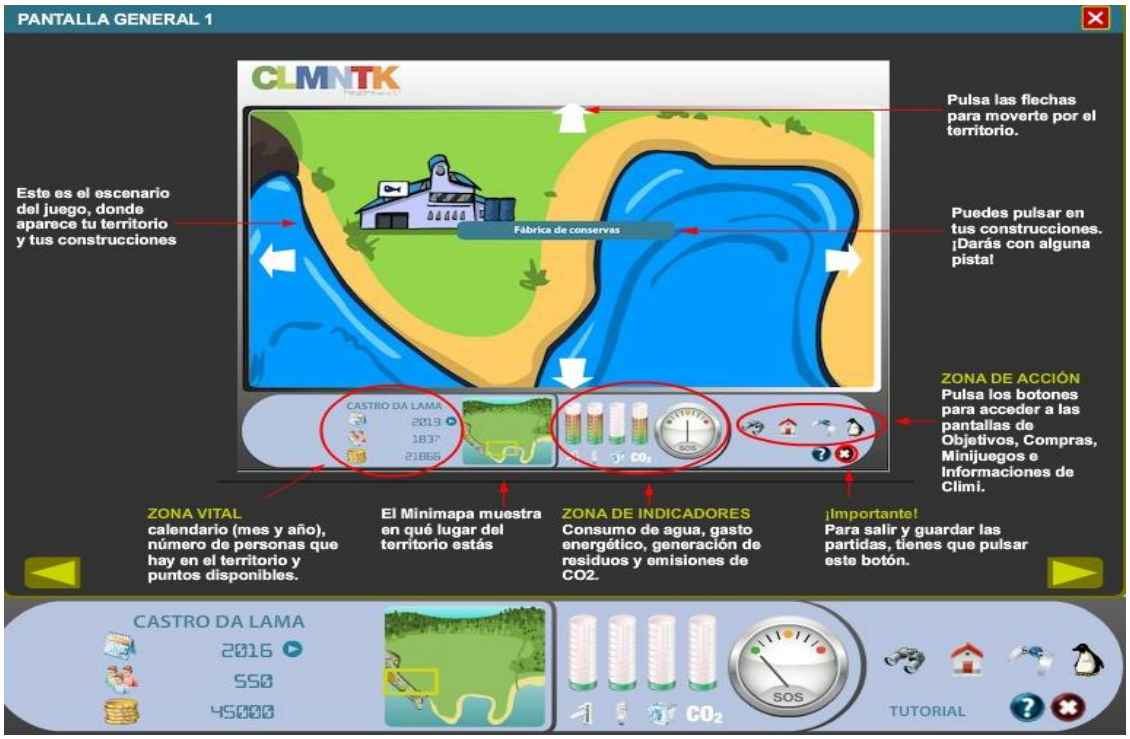


Figura 5. Ejemplo de instrucciones de juego en *Climántica*

A pesar de que la mayoría de estos juegos son para un solo jugador, los docentes pueden considerar el juego por parejas o pequeños ante la falta de ordenadores. La disponibilidad de instrucciones del juego (Figura 5) y el hecho de que los juegos suelan tener una duración máxima de una hora también son un punto a favor a la hora de su uso en el aula.

	Actúa con tu consumo	***Alerta CO2***	***Climántica***	***Misión posible, salvar el planeta***	***My Green Energy Planet***
Nº de jugadores y uso	1, uso individual o colectivo	1, uso individual o colectivo	1, uso individual	1 o 2, uso individual o colectivo	1, uso individual
Tipo de jugador	Explorador/creador	Explorador	Creador	Explorador	Creador
Duración	1 hora (sin contar actividades fuera del juego)	15-20 minutos	Menos de 1 hora	Menos de 1 hora	Menos de 1 hora
Grado de interactividad	Medio-alto	Alto	Alto	Medio-alto	Alto
Misión del juego	El objetivo del juego no es ganar sino concienciar a través de toda la información que aparece sobre los efectos y las causas que afectan al medio ambiente y al ser humano, así como informar sobre las acciones que se pueden llevar a cabo	Se gana aprendiendo a reducir la contaminación en tres escenarios distintos: dormitorio, la calle y la escuela. En cada escenario hay que descubrir, los agentes causantes de una alta emisión de CO2 y contestar bien y rápido a las preguntas	La misión es crear y gestionar un territorio sostenible en 20 años, cumpliendo los siguientes objetivos: proporcionar viviendas y trabajo para la población, construir lugares de ocio, proveer de energía al territorio y atender al clima	Superar todas las pruebas preguntas/respuestas, laberintos, puzzles y crucigramas en el menor tiempo posible	Realizar diferentes acciones sobre diferentes elementos del juego con el fin de crear un planeta sostenible, limpio y feliz sustituyendo las energías antiguas por renovables. Lo que marca el puesto en el ranking es la puntuación "Eco-índice". Este marcador indica puntuación global

Dinámicas	Descubrimiento, narrativa, emociones, expresión	Descubrimiento, habilidad, desafío, narrativa	Desafío, habilidad, progresión, descubrimiento, sensación	Descubrimiento, desafío, narrativa, fantasía	Progresión, descubrimiento, desafío, estatus
Sistema de feedback	Positivo	Positivo y negativo	Positivo y negativo	Positivo	Positivo y negativo
Sistema de recompensas	No	Si, estatus	Si, monedas virtuales, eco-colegios	No	Si, eco-bonos, monedas virtuales
Disponibilidad de instrucciones de juego	Si	Si (explicadas durante el transcurso del juego)	Si	Si	Si
Posibilidad de guardar la partida	No	No	Si	No	Si

Tabla 4. Resultados de la dimensión jugabilidad

Didáctica

Por último, los juegos evaluados presentan distintas curvas de aprendizaje, facilitan el desarrollo de la mayoría de las competencias recogidas por la LOMCE (2015), incluida la competencia matemática en el caso de las simulaciones, y la adquisición de habilidades de pensamiento que establece la taxonomía de Bloom (1956), incluida la creatividad (Figura 6). Como ejemplo, en *Actúa con tu consumo* Eva anima a los jóvenes a escribir sus reflexiones sobre papel, a hacer encuestas a personas de su entorno y a realizar búsquedas de información por Internet, asumiendo el papel de investigadores.

Figura 6. Espacio creativo en *Actúa con tu consumo*

Tal y como muestra la Tabla 5, como aspecto positivo destacamos la interdisciplinareidad de los juegos, permitiendo su uso en varias asignaturas, y como negativo el hecho de que la mayoría de las páginas web de estos juegos no incluyen

guías didácticas con recomendaciones para su implementación en el aula. Además, tan sólo un juego está disponible para estudiantes con diversidad funcional.

	Actúa con tu consumo	***Alerta CO2***	***Climántica***	***Misión posible, salvar el planeta***	***My Green Energy Planet***
Competencias (LOMCE, 2015)	Lingüística; conocimiento e interacción con el mundo físico; la información y competencia digital; social y ciudadana; aprender a aprender; autonomía e iniciativa personal	Conocimiento e interacción con el mundo físico; tratamiento de la información y competencia digital; social y ciudadana; autonomía e iniciativa personal	Matemático; conocimiento e interacción con el mundo físico; la información y competencia digital; social y ciudadana; aprender a aprender; autonomía e iniciativa personal	Conocimiento e interacción con el mundo físico; tratamiento de la información y competencia digital; social y ciudadana; autonomía e iniciativa personal	Matemático; conocimiento e interacción con el mundo físico; la información y competencia digital; social y ciudadana; aprender a aprender; autonomía e iniciativa personal
Habilidades	Recordar, comprender, aplicar, analizar, evaluar, crear	Recordar, comprender	Recordar, comprender, aplicar, analizar, evaluar, crear	Recordar, comprender, aplicar	Recordar, comprender, aplicar, analizar, evaluar, crear
Condiciones de resolución de problemas	Razonamiento productivo, creatividad	Razonamiento reproductivo, memoria	Razonamiento productivo, creatividad	Razonamiento reproductivo, memoria	Razonamiento productivo, creatividad
Curva de aprendizaje	Dificultad baja	Dificultad media	Dificultad alta	Dificultad baja-media	Dificultad alta
Necesidad de conocimientos previos	No	Si	Si	No	Si
Posibilidad de trabajo en grupo	Si	Si	No	Si	No
Accesibilidad	Si, subtítulos	No	No	No	No
Interdisciplinariedad	Si	Si	Si	Si	Si
Acompañamiento de guía didáctica	No	No	No	No	Si
Posibilidad de evaluación del docente	No	Si, a través de una valoración final	No	No	Si, a través de puntos acumulados

Tabla 5. Resultados de la dimensión didáctica

4.3.6. Discusión

Los juegos online ofrecen oportunidades para exponer a los jóvenes a los problemas que van a enfrentar en el futuro y simularlos de forma virtual. Tienen capacidad de ofrecer una comunicación más participativa a través de la interactividad y la inmersión, capaz de hacer frente a la lógica de la distribución de la información imperante en los medios convencionales.

El concepto de interactividad implica, entre otros aspectos, la intervención por parte del usuario sobre el contenido o la transformación del espectador en actor (Aparici & Silva, 2012; Grifeu, 2010). La estructura formal del juego hace que el jugador tenga la libertad de elegir sus propios escenarios y secuencias narrativas, interviniendo así en su contenido. A modo de ejemplo, en *Climántica*, el jugador decide marchar a un nuevo territorio, escogiendo entre un territorio de interior, un territorio abrupto que da al mar

abierto, y un territorio costero. Esta primera elección permite al usuario situarse en una localización significativa, adaptando así la comunicación al propio contexto e interés del usuario.

Estos recursos permiten a los jóvenes convertirse en actores con un rol activo, dejando de ser meros consumidores de información. La personificación es uno de los componentes del juego que facilitan esa inmersión y experiencia directa, dando la opción de asumir papeles de ciertos personajes. En el juego *Misión Posible, Salvar el Planeta*, los jugadores se convierten en superhéroes ecológicos a través de avatares que luchan contra la emisión descontrolada de gases a la atmósfera que provocan el cambio climático. En los juegos de simulación *Climántica* o *My Green Planet*, los jóvenes se adentran en un mundo virtual y asumen los papeles de personajes que tienen que gestionar un territorio y obtener un equilibrio ambiental, energético y social, atendiendo al clima, ¿cómo?, analizando y evaluando la información recibida para tomar decisiones. Los jugadores deben tener en cuenta diversos parámetros a tiempo real, jerarquizando los valores y planificando recursos de forma estratégica.

La evaluación de estos juegos pone también de manifiesto la capacidad de estas herramientas para enmarcar los mensajes de manera alternativa, con una mayor contextualización, un tono alarmista, pero también proactivo, esperanzador y positivo, y poniendo énfasis en las soluciones. Así, la concepción común de que "nuestra actuación personal es irrelevante dada la magnitud del problema y la inacción colectiva", se sustituye por la convicción de que: "sin la implicación de todos, adoptando cambios individuales, participando en la búsqueda de soluciones colectivas y en la demanda de cambios en las políticas estructurales relacionadas con el cambio climático, será difícil lograr cambios efectivos" (Meira-Cartea, 2008). El uso de *feedback*, elogios y recompensas tienen el potencial de incrementar la motivación y sensación de empoderamiento.

Tras la evaluación de estos juegos, cabe mencionar como limitaciones de estos recursos la falta de instituciones científicas en la producción de juegos, aportando fiabilidad y rigurosidad a los contenidos, o la decisión de combinar diversas problemáticas medioambientales en la temática de un mismo juego, que puede dar lugar a la confusión entre los jugadores a la hora de diferenciar fenómenos o establecer relaciones causales. Los juegos evaluados también muestran una preferencia por el término "cambio climático" sobre "calentamiento global". De hecho, según Poole (2006), el término cambio climático es un modo menos "amenazador" de decir calentamiento global y menos relacionado con la industria del petróleo.

Si bien este artículo no se enfoca en el proceso concreto de implementación de los juegos en el aula, la evaluación de la dimensión didáctica de estos juegos ofrece algunas claves y aspectos a tener en cuenta en la toma de decisiones de los docentes de educación secundaria. Así, los juegos evaluados muestran distintas curvas de aprendizaje, facilitan el desarrollo de la mayoría de las competencias recogidas por la LOMCE (2015), incluida la matemática en el caso de las simulaciones, y promueven la adquisición de habilidades de pensamiento que establece la taxonomía de Bloom (1956), incluida la creatividad. Es decir, que el usuario de juegos además de entretenerse y adquirir nuevos conocimientos, puede desarrollar competencias y habilidades necesarias para la construcción de una ciudadanía activa en el siglo XXI (Mitchell & Savill-Smith, 2004; Reig & Vílchez, 2013), tales como el pensamiento

crítico. Juegos como *Actúa con tu Consumo* abren explícitamente un espacio para la reflexión al inicio de la misión, en este caso, reflexionar sobre la relación entre hábitos de consumo-cambio climático y sobre los límites de crecimiento de nuestra sociedad. El avatar que hace de hilo conductor de la historia se presenta al usuario del juego de la siguiente manera: "*Hola soy Eva, una joven consumidora como tú. Quería preguntarte si eres consciente del poder que tenemos como consumidores solo realizando pequeños gestos en nuestra vida diaria. Yo ya lo soy. Descúbrelo navegando por mi ciudad"*.

Sin embargo, en términos más prácticos, se echan en falta posibilidades para estudiantes con diversidad funcional, así como un acompañamiento de guías didácticas con el juego que pueda facilitar su inclusión en el aula. A la hora de introducir el juego en clase, autores como Lacasa (2012) recomiendan a los docentes seguir los siguientes pasos: dialogar con el alumnado sobre el juego e introducir el tema en grupo planteando preguntas y despertando interés; jugar en situaciones de pequeño grupo; debatir y reflexionar tras la sesión de juego, comentar qué ha ocurrido ayudando a tomar conciencia de los problemas, a formularlos y descubrir caminos. Puesto que uno de los obstáculos de los docentes es la falta de tiempo y algunos de los juegos evaluados pueden alargarse más de una hora, como es el caso de las simulaciones, otra de las recomendaciones es dejar que los alumnos jueguen en casa y reservar el tiempo en el aula para debatir y reflexionar acerca del juego. A pesar de que los jóvenes pueden entender a la perfección las misiones del juego o cómo ganar una partida, es particularmente importante que entiendan también que los principios del juego y sus contenidos se reflejan en la vida real.

4.3.7. Conclusiones

Ante los desafíos de la comunicación y educación sobre cambio climático, los juegos online sobre cambio climático se perfilan como herramientas alternativas para fomentar la concienciación entre los jóvenes. La interactividad y la inmersión son factores clave, a diferencia de los medios convencionales. Los juegos online ofrecen oportunidades para exponer a los jóvenes a los problemas que van a encarar en el futuro y experimentarlos de forma virtual, por lo general, adoptando roles de personajes que han de ser capaces de tomar decisiones sostenibles. En el proceso de recogida, evaluación y aplicación de la información que se va generando durante el juego, los jóvenes desarrollan no sólo pensamiento crítico, sino otro tipo de habilidades necesarias para su desarrollo personal y para afrontar las adversidades expuestas por el calentamiento global. Se abren espacios de reflexión, se abordan temáticas relevantes al cambio climático y se genera una psicología positiva basada en la búsqueda e implementación de soluciones. Como componente esencial de la interactividad, la retroalimentación, en ocasiones acompañada por elogios y recompensas, juega un papel importante en este proceso.

Entre las limitaciones del estudio, destacamos que la muestra de juegos es pequeña y que por lo tanto no podemos ofrecer conclusiones generalizables a toda la población de juegos online en cambio climático producidos en España. Si bien nuestra evaluación no es en absoluto exhaustiva, sí pretendemos con ello aportar una primera aproximación a un campo de estudio emergente y escasamente explorado. Aunque los videojuegos no son la panacea ni debieran sustituir a las clases tradicionales, sí existe la necesidad de prestar más atención a estas herramientas de comunicación y educación.

Teniendo en cuenta que los *serious games* de este tipo logran contar en 15 minutos de forma dinámica conceptos científicos complejos, una línea de investigación abierta es la aplicación de estas herramientas en contextos educativos. Futuras investigaciones han de contemplar asuntos como el impacto real y la efectividad de estos juegos sobre el alumnado, así como qué elementos de los juegos comerciales que más éxito han tenido entre los jóvenes podrían trasladarse a los *serious games*. En este sentido, se recomiendan estudios sobre cómo diseñar y mejorar los juegos online para que tengan un mayor impacto sobre la concienciación, conocimientos y actitudes de los jóvenes. No sólo la mentalidad de los jugadores y su contexto influyen en el impacto de los juegos, sino también la manera en la que los objetivos comunicativos y de aprendizaje se canalizan mediante el diseño de los juegos a través de sus dinámicas, mecánicas y componentes (Mitgush & Alvarado, 2012).

4.3.8. Referencias bibliográficas

Aparici, R., & Silva, M. (2012). Pedagogía de la Interactividad. *Comunicar, 38*(XIX), 51-58. doi: 10.3916/C38-2012-02-05

Bloom, B. S. (1956). *Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain*. New York: David McKay Co Inc.

Cooper, C. B. (2011). Media Literacy as a Key Strategy Toward Improving Public Acceptance of Climate Change Science. *BioScience, 61*(3), 231-237. doi: 10.1525/bio.2011.61.3.8

DEV (2015). *Libro blanco del desarrollo español de videojuegos*. Madrid: DEV

European SchoolNet (2009). *How are digital games used in schools?* Brussels: European SchoolNet

Frasca, G. (2007). *Play the Message: Play, Game and Videogame Rhetoric* (Unpublished doctoral dissertation). IT University of Copenhagen

Fundación Mapfre (2013). *La respuesta de la sociedad española ante el cambio climático 2013.* Madrid: Instituto de Prevención Salud y Medioambiente

Gee, J.P. (2004). *Lo que nos enseñan los videojuegos sobre el aprendizaje y el alfabetismo.* Archidona: Aljibe

Gee, J. P. (2008). Being a lion and being a soldier: learning and games. In J. Coiro, M. Knobel, C. Lankshear, & D. J. Leu (Eds.), *Handbook of Research on New Literacies* (pp.1023–1036). New York: Routledge

Grifeu, A. (2010). *El documental interactivo. Evolución, caracterización y perspectivas de desarrollo*. Barcelona: Editorial UOC

Groffman, P.M., Stylinski, C., Nisbet, M.C., Duarte C.M., Jordan, R., Burgin, A., Previtali, M.A., & Coloso, J. (2010). Restarting the conversation: Challenges at the interface between ecology and society. *Frontiers in Ecology and the Environment, 8*, 284–291

Johnson, L., Smith, R., Willis, H., Levine, A., & Haywood, K. (2011). *The 2011 Horizon Report*. Austin, Texas: The New Media Consortium.

Juul, J. (2005). *Half-Real: videogames between real rules and fictional worlds.* Cambridge, MA: The MIT Press

Katsaliaki, K., & Mustafee, N. (2014). Edutainment for Sustainable Development: A survey of Games in the Field. *Simulation & Gaming, 1*(26). doi: 10.1177/1046878114552166

Kim, A. J. (2012). *Social engagement: who´s playing? How do they like to engage?* Recuperado de http://goo.gl/BFTnhh

Lacasa, P. (2011). *Los videojuegos. Aprender en mundos reales y virtuales.* Madrid: Ed. Morata

León, B. (2013). *El periodismo ante el cambio climático. Nuevas perspectivas y retos*. Barcelona: UOC

Liarakou, G., Sakka, E., Gavrilakis, C., & Tsolakidis, C. (2012). Evaluation of serious games, as a tool for education for sustainable development. *EURODL (Special issue),* 96-110. Recuperado de ERIC

Liu, S., & Ding, W. (2009). An approach to Evaluation Component Design in Building Serious Games. En M. Chang, R. Kuo, G.-D. Chen & M. Hiroshe (Eds.), *Edutainment ´09 Proceedings of 4th International Conference on E-learning and Games: learning by playing* (pp. 141-148). Berlin: Springer

LOMCE - *Ley Orgánica para la Mejora de la Calidad Educativa* de 2015. Orden ECD/65/2015, de 21 de enero

Maibach, E., Nisbet, M., Baldwin, P., Akerlof, K., & Diao, G. (2010). Reframing Climate Change as a Public Health Issue: An Exploratory Study of Public Reactions. *BMC Public Health, 10*, 299–309. doi: 10.1186/1471-2458-10-299

Martí-Parreño, J., Méndez-Ibáñez, E., Giménez-Fita, E., & Queiro-Ameijeiras, C. (2015). El uso de la gamificación en la educación superior: propuesta de una ficha de análisis ludológico-narratológico. In M.A Ruiz Rosillo (Ed.), *XII Jornadas Internacionales de Innovación Universitaria Educar para transformar: Aprendizaje experiencial* (pp. 103-111). Madrid: Universidad Europea de Madrid

Meira-Cartea, P.A. (2008). *Comunicar el cambio climático. Escenario social y líneas de actuación.* Madrid: Ministerio de Medio Ambiente y Medio Rural y Marino-Organismo Autónomo de Parques Nacionales

Michael, D., & Chen, S. (2005). Serious Games: games that Educate, Train and Inform. Muska & Lipman/Premier-Trade

Mitchell, A., & Savill-Smith, C. (2004). *The use of computer and video games for learning: A review of the literature*. London: Learning and Skills Development Agency

Mitgutsch, K., & Alvarado, N. (2012). Purposeful by Design? A serious game design assessment framework. *Proceedings of the International Conference on the Foundations of Digital Games* (pp. 121-128). New York: ACM

Moser, S.C. (2010). Communicating Climate Change: History, Challenges, Process and Future Directions. *WIREs Climate Change, 1*, 31-53. doi: 10.1002/wcc.011

Murray, J. (1999). Hamlet *on the Holodeck.* Cambridge, MA: The MIT Press

Nisbet, M., & Scheufele, D. (2009). What's Next for Science Communication? Promising Directions and Lingering Distractions. *American Journal of Botany, 96*, 1767–1778

Pérez-Latorre, O. (2010). *Análisis de la significación del videojuego. Fundamentos teóricos del juego, el mundo narrativo y la enunciación interactiva como perspectivas de estudio del discurso*. (Tesis de doctorado). Universitat Pompeu Fabra, Departament de Comunicació, Barcelona

Piñuel-Raigada, J.L., & Teso-Alonso, G. (2012). Los temas de referencia abordados en las noticias de los informativos televisivos en España con ocasión de las cumbres del Cambio Climático en Cancún y Durban. In J.L. Piñuel-Raigada et al. (Eds.), *Comunicación, controversias e incertidumbres frente al consenso científico acerca del cambio climático*. Cuadernos Artesanos de Latina, 30

Poole, S. (2006). *Unspeak: words are weapons: the language of everyday deception*. London: Little Brown

Prensky, M. (2001). Digital natives, digital immigrants. *On The Horizon*, *9*(5), 1-6. doi: 10.1108/10748120110424816

Reckien, D., & Eisenack K. (2013). Climate Change Gaming on Board and Screen: A review. *Simulation and Gaming, 44*(2-3), 253-271. doi:10.1177/1046878113480867

Reig, D., & Vílchez, L.F. (2013). Los *jóvenes en la era de la hiperconectividad: tendencias, claves y miradas*. Madrid: Fundación Telefónica y Fundación Encuentro.

Ruiz-Dávila M., Montero-Pascual M.E., Díaz-Tejero B., & López-Fernández de Córdoba C.M (2008). Videojuegos para tender puentes. Diálogo y aprendizaje puestos en juego. *Comunicación y Pedagogía, 225*, 39-45

Scapolo, F., & Miles, I. (2006). Eliciting expert´s knowledge: A comparison of two methods. *Technological Forecasting and Social Change, 73*, 670-704

Schafer, M. (2012). Online communication on climate change and climate politics: literature review. *WIREs Climate Change, 3*(6), 527–543. doi: 10.1002/wcc.191

Tapscott, D. (2009). *Grown up digital*. New York: McGraw-Hill.

Tejeiro, R., & Pelegrina, M. (2003). *Los videojuegos: qué son y cómo nos afectan*. Barcelona: Ariel.

Werbach, K., & Hunter, D. (2012). *The Gamification Toolkit*. Pennsylvania: Wharton Digital Press

Wu, J., & Lee, J. (2015). Climate change games as tools for educational and engagement. *Nature Climate Change, 5*, 413-418. doi: 10.1038/NCLIMATE2566

4.4. Analyzing climate change communication through online games: development and application of validated criteria

Article 4: Ouariachi, T., Olvera-Lobo, M.D., & Gutiérrez-Pérez, J. (2017). "Analyzing climate change communication through online games: development and application of validated criteria". *Science Communication, 39* (1), 10-44. DOI: 10.1177/1075547016687998

In search of innovative approaches capable of connecting climate change issues with teenagers, scholars and practitioners have become interested in harnessing the potential of gaming for advancing climate change communication. This article aims to propose a set of criteria, validated by experts through the Delphi method, by which to analyze communicative features of online climate change games. The use of the criteria is illustrated with an evaluation of a sample of Spanish games to which we apply qualitative content analysis, narratology, and ludology techniques. Our findings reveal some positive communicative trends in terms of narratives, contents, and gameplay.

4.4.1. Introduction

Climate change is an inevitable and pressing global challenge with long-term implications for the sustainable development of all countries. In the fight against climate change, young people are potentially well positioned to trigger an ambitious and long-term societal change, adopting sustainable attitudes and behaviors in energy use from early ages and influencing their parents' decisions. However, research has shown that awareness and commitment are still limited (Bofferding & Kloser, 2015): Youth is even less concerned about the environment than older age-groups and less likely to engage in environmentally responsible actions (Fielding & Head, 2012; Partridge, 2008).

Science communication has for a long time pointed to the "information deficit model" (little amount of information available), which holds that people lack knowledge and interest to make decisions, as the main problem (Nisbet & Scheufele, 2009). Recently, however, several studies have confirmed that many climate communications efforts have failed, and not necessarily because of little information being available (Cooper, 2011; Moser & Dilling, 2011; Reckien & Eisenack, 2013).

Concerns are related with the way climate change information is conveyed: Scholars acknowledge the limitations of conventional media in delivering information, such as the one-way transmission of messages, which transforms the audience into passive consumers of information; the lack of contextualization, which provokes confusion with other environmental issues; and the negative and alarmist tone of the content, which instead of motivating people to take action often evokes paralysis or apathy (Aparici & Silva, 2012; Díaz-Nosty, 2013; León, 2014; Moser, 2010; Reig, 2010). Their studies have called for new communication strategies to be found, capable of connecting with targeted audiences such as the so-called interactive generation (Aguaded-Gómez, 2011) or digital natives (Prensky, 2001). Online games might offer these possibilities.

Scholars and practitioners have become interested in harnessing the potential of gaming for advancing communication and education (Gee, 2004; Mendler de Suarez, Suarez, & Bachofen, 2012): They can offer experiential learning, transforming passive consumers of information into active players who absorb new information more readily and

simulate unfamiliar circumstances that are not possible in real life. Climate change games are considered serious games because their purpose exceeds pure entertainment. Their goals can be summarized in (a) making players aware of the challenges associated with global warming, (b) providing knowledge and understanding with the issue of climate change, and (c) encouraging players to take actions and develop solutions (Reckien & Eisenack, 2013; Wu & Lee, 2015).

The first climate change game was designed more than 30 years ago, as a board game that modeled increasing levels of CO_2 in the atmosphere (Wu & Lee, 2015), and since then climate change games have increased and diversified: card games such as *Keep Cool*, where players represent groups of countries that negotiate economic growth and climate change mitigation; simulations based on peer-reviewed scientific data that allow for the manipulation of variables such as energy consumption and population growth to model the effects on world climate, like those collected on the website *Climate Interactive*; or mobile games like *Climate Mission 3D*, where players learn how to reduce their carbon footprint as they play a series of minigames. In the past 10 years, climate change games have experienced most progress (Reckien & Eisenack, 2013), especially in an online format, with examples like *Clim'Way* (2010), *BBC Climate Challenge* (2010), *EnerCities* (2011), and *CityOne* (2011).

Discussions have begun on the analysis of serious games in general (Liarakou, Sakka, Gavrilakis, & Tsolakidis, 2012; Liu & Ding, 2009; Martí-Parreño, Méndez-Ibáñez, Giménez-Fita, & Queiro-Ameijeiras, 2015; Mitgutsch & Alvarado, 2012), and on the analysis of sustainability and climate change games in particular: The research by Katsaliaki and Mustafee (2014) proposes a review of games on sustainability produced in English, analyzing underlying characteristics such as game availability; number of players, their roles, and their target age; game validation; graphics; or stakeholder involvement in game development. Reckien and Eisenack (2013) analyze climate change games on board and screen developed in English or German, using indicators such as year of appearance, format of game, actors involved, temporal development, or scale of issues. Wu and Lee (2015) provide a general overview of climate change games in English, comparing different formats and features but without proposing a systematic analysis. These studies are calling to expand the research in climate change gaming.

As we can see, previous research in this field mostly focuses on general characteristics that can help identify the game without further going into details. Also, these studies mostly focus on English-speaking games; however, there is a need to pay more attention to games produced in non-English countries and languages. Spain for instance is currently experiencing its video game development "golden age"; it ranks fourth in Europe and ninth in the world (DEV, 2015). A growing number of multinationals are founding studios in Spain, and creativity of Spanish young professionals is being supported by universities, which have established training programs in the sector in recent years (DEV, 2015).

Taking into account the increased development of online climate change games and their potential to connect with young people—less concerned and engaged than older age-groups—we need to better understand the communicative nature of these types of games: how these games are transmitting climate change issues through their narratives and contents, the meanings hidden behind the design, and the preferred techniques chosen by producers. Having said that, the objectives of this research are the following:

1. To develop and propose a set of validated criteria by which to analyze communicative features of online climate change games, integrating a narratological (understands the game as a medium to generate stories and transmit contents) and a ludological view (pays attention to the meanings hidden behind the design)
2. To illustrate the use of the criteria by analyzing a sample of online climate change games, using Spain as a case study
3. To demonstrate usefulness of the criteria in examining communication trends and techniques within this class of games

The development of validated criteria could help teachers select appropriate games as pedagogical resources, game developers design new games, and researchers advance thinking in the area of games and science communication. An illustration and demonstration of the criteria through the analysis of available climate changes games on the web would be valuable and of interest in order to examine communication trends and techniques within this class of games.

This article introduces the field of online games that focus on climate change, offering a conceptual, theoretical, and methodological framework for analysis. We will outline our findings, and the implications for this field.

4.4.2. Conceptual and Theoretical Approaches

Online games are video games that use computer technology, allowing players to interact with the machine in real time and action to take place in a visual format, with a unique feature in that they are accessible via a Web browser and available on the Internet (Tejeiro & Pelegrina, 2003). When talking about *online climate change games*, we are therefore focusing on games available on the Internet specifically themed around climate change and/or topics related to this phenomenon, with communicative and educational purposes, which does not exclude that they can involve some degree of fun and entertainment. These types of games are then considered as *serious games*, understood as games intended to fulfill a purpose and to convey ideas and values (Frasca, 2007).

The field of game studies took around 30 years to develop after the first successful video game appeared, and in 2011, Espen Aarseth from IT University of Copenhagen founded the first academic journal to study video games, *Game Studie*s. Since then, several models to analyze games have been proposed from several scientific disciplines. These are some of them:

1. Sociocultural dimension and video game reception studies: education and online games studies (Gee, 2004), cultural and reception studies (Taylor, 2006), or psychosocial effects (Egenfeldt-Nielsen, Smith, & Pajares-Tosca, 2008)
2. Design, formal dimension, and significance studies: game design theory (Salen & Zimmerman, 2004), narratology (Murray, 1999), ludology (Juul, 2005), or procedural content generation (Shaker, Togelius, & Nelson, 2016)

Rodríguez-Hoyos and João Gomes (2013) found out in a literature review of academic studies on serious games that the majority of the research of these types of games falls into the first category, concretely studies that analyze its use to improve learning or social competences. The second category has as the main antecedent literature or

cinema studies, in which analyses are focused on the work itself, independently of the reception context. Our study is positioned within this second group of studies. In this domain, scholars have disagreed over time on how to approach video game analysis; the spectrum ranges from the affirmation of the new possibilities of storytelling to the denial of the narrative quality of video games; the disagreement has been called "narratology versus ludology debate" (Frasca, 2007).

Narratology refers to the branch of knowledge that deals with the structures and function of narrative (Murray, 1999); narratologists believe that games should be understood as a storytelling medium or a novel form of narrative and therefore should be analyzed using theories of narrative. They see video games as a broad form of narrative expression such as novels or movies. After Janet Murray (1999) published *Hamlet on the Holodeck*, in which she discusses the technical possibilities and the new ways of storytelling in the cyber age, several researchers started taking the same approach by studying online games as a narrative form. Other important works in the field of narratology and games are *Narrative as Virtual Reality* (Ryan, 2001) and *More Than a Game: The Computer Game as Fictional Form* (Atkins, 2003).

Ludology defends the study of structures and features of games on their own terms, not as a form of narrative expression such as novels. Ludologists believe in studying "games as games," focusing on the rules, game world, and gameplay; they emphasize the importance of game design in both the formal composition and the transmission of meaning. For instance, in an analysis of *The Sims*, Pérez-Latorre (2010) suggests the use of rewards such as virtual money in game design can communicate implicit meanings such as consumerism and capitalism values. A representative work in this field is *Half-Real: Video Games Between Real Rules and Fictional Worlds* (Juul, 2005), which examines how rules provide challenges, learning, and enjoyment for players and how a game cues the player into imagining its fictional world.

The theoretical perspective of this study supports an intersection between narratology and ludology, a positioning shared by other authors such as Pérez-Latorre (2010) and his "Social Discourse of Video Games Analysis Model," which also integrates both perspectives for game analysis (Figure 1). We cannot treat video games only as a narrative form ignoring its peculiarities, but at the same time, the fact that video games are games by no means excludes them from having narrative qualities. Every video game has a message to transmit and a certain perspective on the world, on what is victory, and on how to achieve it. From narratology, we take into consideration techniques such as observing the role of the player in its environment or the story lines with the unfolding of plots and, from ludology, the analysis of micro structures in relation to the overall design, the game dynamics, and mechanics. By combining a narratological and a ludological perspective, we can develop appropriated criteria capable of analyzing the communicative features of online climate change games in a holistic and integrating manner.

Online games can therefore be studied as (audiovisual and digital) communicative media; in the past they were mostly addressed as technological objects, commercial products, or educative tools. Gombrich (2004) maintains that there is no such thing as an innocent game, while Huizinga (1938) says that every game means something.

4.4.3. Methodology

The research presented in this article is characterized as interdisciplinary, exploratory, and evaluative. Our qualitative study makes use of different methods to reach our objectives. In order to develop criteria that reach consensus among experts to analyze communicative features of online climate change games, we make use of the Delphi method; in order to illustrate the use and usefulness of the criteria, we apply those criteria through an analysis of a sample of games in Spain, using three approaches to enrich the analysis: content analysis, which provides more quantitative information, as well as narratology and ludology, focusing on the relationships between game narrative and design. This compensates for the logistical challenges of using traditional content analysis strategies as a single method for analyzing video games, which are technologically more sophisticated than other communication media, making it more difficult for human coders to analyze them (Dudo, Cicchirillo, Atkinson, & Marx, 2014, p. 225; Schmierbach, 2009).

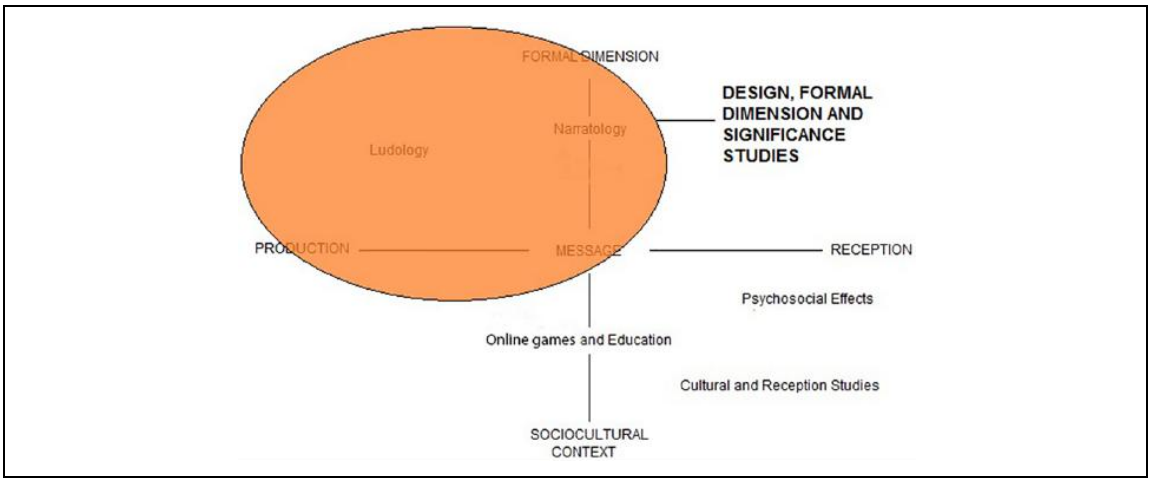


Figure 1. Study's theoretical positioning: Representation of theoretical perspectives for game analysis integrated into communication sciences study delimitation around five variables: production, reception, formal dimension, contextual dimension, and message. *Source*. Adaptation from Pérez-Latorre (2010).

Developing the Criteria for Analysis

To achieve the first objective, we use the Delphi method, a structured and interactive process to collect opinions that establish consensus, based on the experiences and judgments of experts (Scapolo & Miles, 2006). This method is usually chosen among others methods when we are dealing with a novel field with not enough data to interpret the study object and there is a need to clarify analysis categories or criteria. Another reason is that the Delphi method aims at maximizing the advantages of methods based on expert groups and reduces its disadvantages by deleting negative interactions with the goal of achieving agreement among experts (Linstone & Turoff, 1975). Previous studies have successfully used the method to develop a set of criteria for different purposes: to define quality in regulated and nonformal sociocultural animation and free time education (Pozo-Llorente, Gutiérrez-Pérez, & Rodríguez-Sabiote, 2007), to evaluate media literacy among teachers (Gozálvez-Pérez, González-Fernández, & Caldeiro-Pedreira, 2014), or to inquire into potential applications for massively multiplayer online role-playing games as constructivist learning environments in formal

K-12 education (Wagner, 2008). To our knowledge, this is the first time that the Delphi method is used to develop a set of criteria in the field of online climate change games.

First of all, we designed the following protocol:

1. We defined the objective: to develop criteria that reach consensus among experts to analyze communicative features of online climate change games, from a narratological and ludological point of view.[1]
2. We established the characteristics and profiles of the experts: The experts were chosen based on their theoretical and/or practical knowledge of communication, education, games, and climate change. In our case, 13 experts were contacted by e-mail to participate and all of them agreed to be part of the panel. According to Rand Corporation, a minimum of 7 experts and a maximum of 30 are considered as valid (Astigarraga, 2008). They included professors and researchers at universities, communication specialists at scientific institutions, educators and teachers at high schools who employ games and gamification, and game designers. They came from Spain, the United States, and the Netherlands.
3. We identified a first list of dimensions (categories of analysis, which serve as guidelines to organize the criteria) and criteria (indicators of analysis, elements to consider when analyzing games) that integrate both narratology and ludology perspectives to share with the experts, identified through a literature review of previous studies in the field (Bloom, 1956; European SchoolNet, 2009; Katsaliaki & Mustafee, 2014; Kim, 2012; Lacasa 2011; León, 2014; Liarakou et al., 2012; Liu & Ding, 2009; Martí-Parreño et al., 2015; Meira-Cartea, 2008; Mitgutsch & Alvarado, 2012; Moser & Dilling, 2011; Pérez-Latorre, 2010; Piñuel-Raigada & Teso-Alonso, 2012; Reckien & Eisenack, 2013; Werbach & Hunter, 2012).
4. We set up a calendar, a communication strategy, and the validation process: Communication was maintained via e-mail and the process and exchange of opinions were interactive and anonymous—their names were not revealed. Experts emitted their opinions and were able to reconsider their position when getting feedback about the results from the other experts. Consensus was taken into consideration as a guiding principle during the entire process; therefore, once consensus and stability of results were achieved the process was concluded. In our study, three consulting rounds were sufficient to conclude the process (Figure 2).

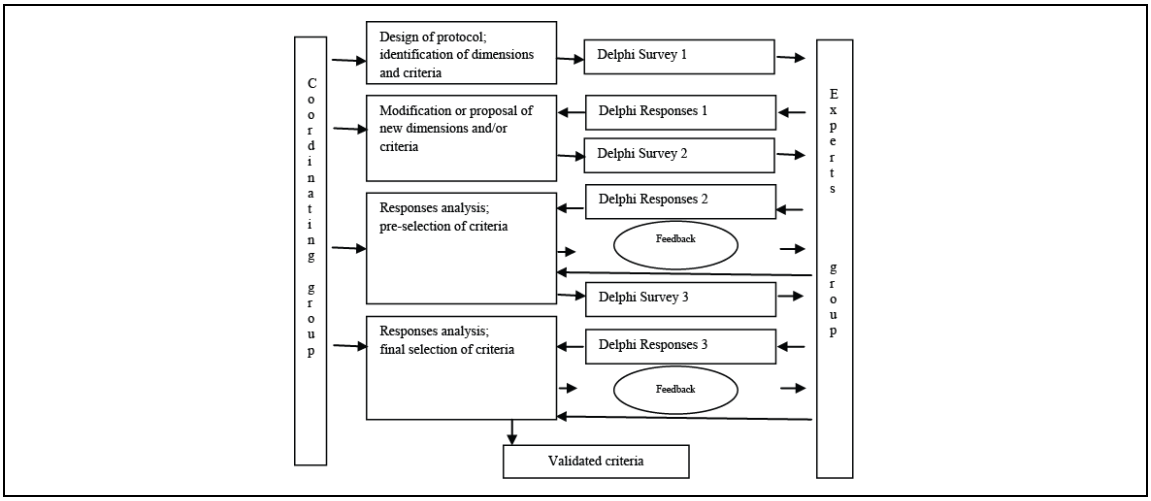


Figure 2. Delphi process in our study. Source. Adaptation from Pozo-Llorente, Gutiérrez-Pérez, & Rodríguez-Sabiote (2007)

In the first round, we shared with the experts the objective stated above and the list with the first group of dimensions and criteria identified by the authors. We asked them to modify or propose new dimensions and/or criteria if necessary. From the beginning, opinions were quite favorable. Nevertheless, they also proposed some appreciated changes. For instance, next to "narratology" and "ludology" dimensions, "identification" was also suggested; "narratology" dimension was divided into two different ones: "narrative" and "contents"; "ludology" dimension was recommended to be called "gameplay"; and some new criteria were added (Figure 3).

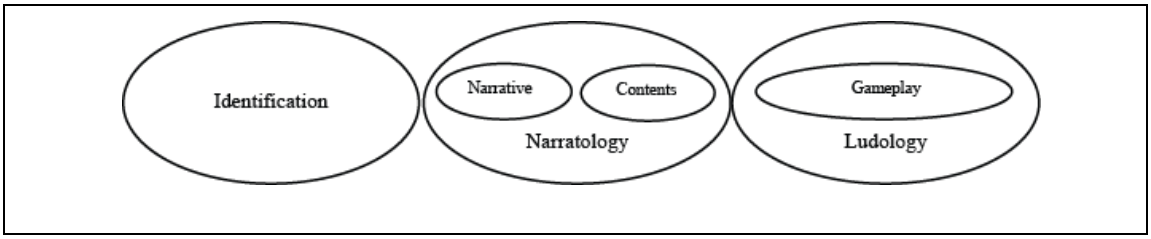


Figure 3. Dimensions restructure after first consulting round.

The criteria were then divided into these dimensions:

- Identification: features that help identify and locate the game
- Narrative: analysis of the narrative and fictional context elements
- Contents: analysis of the information and messages transmitted about climate change
- Gameplay: analysis of the game design and formal structures

The second consulting round consisted of a questionnaire in which experts assessed in ordinal terms (1 = low, 2 = medium, 3 = high) the relevance and usefulness of the criteria to analyze communicative features of online climate change games, aiming at identifying common and conflicting viewpoints and achieving a first consensus in the selection. The criteria that got a consensus of 90% (high + medium) were selected. This percentage represents a robust value for the selection of criteria, while it differentiates with a tolerance margin of 10% the possibilities of discrepancies among experts. In this round, 13 of the initial 49 criteria proposed to study the communicative elements of games did not get the established consensus.

In the third and last round, we requested a final assessment of the 13 criteria that did not pass the second phase, in which they had to confirm whether or not they should remain outside of the final set of criteria. Experts agreed that 8 of the 13 criteria should remain outside. Therefore, a total of 41 criteria were part of the final set (Table 1). At this stage, consensus and stability of results were achieved, and the process was therefore concluded. Variability in opinions disappeared, but also participation of experts was reduced and only 9 out of 13 took part in this round—3 from the area of communication and climate change, 3 from education, and 3 from video games and gamification. We present in Table 1 the proposed 41 criteria, categorized into four dimensions. In addition, we add a column with definitions and categories (when applicable) of each criterion to enable the reader to apply the criteria themselves.

Dimensions	Criteria	Description / Categories
Identification	1. game title	*name of the game*
	2. URL	*address on the World Wide Web*
	3. location on the web	*the game can be located on an independent website, a section of the producer website or on a external and non-related website (e.g. game database)*
	4. name/type of producer	*institution behind the production of the game* categories: national government, regional government, provincial government, local government, private sector, educative institution, communication media, scientific institution, NGO, intergovernmental organizations, partnerships, other
	5. availability of an app	*existence of an application for mobile phones or tables*
	6. free of charge	*the game can be free of charge or not*
	7. language/s	*language options available to play the game*
	8. target audience	*main public addressed in the game*
	9. communicative purpose	*communicative intentions of the game* categories: familiarity with the topic, raising awareness of causes and consequences, promote change of attitudes and behaviour, development of solutions and ideas
	10. brief description	*summary and overview of the game*
Narrative	11. relevance of narrative	*narrative elements can acquire importance or be irrelevant* categories: high, medium, low
	12. existence of a narrator	*the use of a written or spoken commentary to convey a story* categories: yes, no
	13. global storyline	*story in its entirety, the logical or causal succession of the events; story structures can be lineal (leading to a single endpoint), multi-lineal (leading to an indefinite endpoints) or gnoseological (no clearly defined aim)*
	14. character depiction	*characteristics, qualities and roles of the character/avatar* categories for roles: scientists, politician, entrepreneur, major, superhero, ordinary citizen, farmer, policy-maker, other
	15. representation of the environment	*the world in which the character develops*
	16. dimension/space	*general context of the scenarios* categories: real, fictitious
	17. dimension/scale	*scale of the scenarios* categories: global, national, regional, local, combination
	18. dimension/time	*period in time that the story spans* categories: past, present, future, combination
Contents	19. term used	*terminology used to describe the phenomenon being studied* categories: climate change, global warming, both, none
	20. existence of false concepts and misconceptions	*erroneous beliefs that are widely held in relation to climate change (e.g. ozone depletion as a cause)* categories: yes, no
	21. explicit use of scientific concepts	*definition of climate change terms (E.g. greenhouse effect)* categories: yes, no
	22. explicit use of information sources	*sources of information being cited (E.g. source: NASA)* categories: yes, no
	23. convergence with social networks	*links to social networks are included (E.g. Facebook, Twitter)* categories: yes, no
	24. message frame/ climate change focus	*main approach to respond to climate change* categories: mitigation, adaptation, both
	25. message frame/ main theme	*main topic being addressed* categories: energy, water, waste management, transport,

		consumption, biodiversity, urban planning, disaster risks, international negotiations, other
	26. message frame/ promotion of actions	*activities promoted in the game*
	27. message frame/ causes	*attribution to the origins of climate change* categories: natural causes, human action, both, not applicable (the game does not mention any cause)
	28. message frame/ consequences	*effects of climate change* categories: glacial melting, desertification and drought, extreme meteorological events, sea level rise, temperature increase, threat to ecosystems, health problems, political consequences, economic consequences, social consequences, other, not applicable (the game does not mention any consequence)
	29. message frame/ tone	*values and emotions given to the topic* categories: alarmist, sensationalist, informative, uncertainty, protest, hope, pro-action, directness, caring, humorous, other
	30. Images	*visual representations*
Gameplay	31. number of players	*how many users can play in a single in the game*
	32. type of use	*The game offers different options to play* categories: individual, multi-player
	33. player type	*players' profile depending on their interests* categories: collaborator, exploratory, competitor, creator
	34. degree of interactivity	*user intervention in the content* categories: high, medium, low
	35. length of playing	*time employed to play the game*
	36. game misión	*key actions to win the game*
	37. game dynamics & mechanics	*general structure of the game, elements that enable the player to become immersed; rules and challenges* categories for dynamics: fantasy, challenge, comradeship, discovery, expression, emotions, progression, ability, status, other categories for mechanics: decision-making, opportunities, competition, cooperation, personalization, resource collection, rewards, target shooting, memory retention, calculation, turns, other
	38. feedback systems	*message that the player receives in light of certain actions* categories: positive, negative, both
	39. reward system	*actions that incentivize and the rewards themselves* categories: yes, no
	40. availability of game instructions	*the website or game itself offers instructions on how to play* categories: yes, no
	41. possibility of saving the game	*option to save the game and play another time* categories: yes, no

Table 1. Analysis Dimensions and Criteria.

Analysis of the Games

The analysis of the games was carried out by two researchers who played the games and used a form that contained all the Delphi criteria presented above. They applied three different but complementary approaches: qualitative content analysis, narratology, and ludology. From a narratological perspective, we observed the relevance of narrative and existence of narrators (Criteria 11 and 12), the story lines with the unfolding of plots (Criterion 13), character depiction (Criterion 14), the role of the player in its environment (Criterion 15), and the spatial and temporal dimensions (Criteria 16, 17, and 18). From a ludological point of view, we focused on the analysis of microstructures in relation to the overall design, describing game dynamics and mechanics (Criterion 37), the feedback system (Criterion 38), use of rewards (Criterion 39), and other important features (Criteria 31, 32, 33, 34, 35, 36, 40, and 41). In addition, the qualitative content analysis was used for those Delphi criteria that could be

quantified (Criteria 4, 9, 11, 12, 14, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 27, 28, 29, 32, 33, 34, and 37). Qualitative content analysis focuses on manifest and latent features—unobserved concepts that cannot be measured directly but can be represented (Merkl-Davies & Koller, 2012)—and it entails quantification by coding frequencies to detect patterns in the data, in our case, preferred techniques among game producers and trends in online climate change game development.

Levels, missions or episodes were used as analysis units, similar to scenes in movies or strip-frames in comics. Coding followed a deductive approach- categories were developed a priori by drawing on relevant prior research (Table 1). In qualitative content analysis, the emphasis is on achieving consistency of interpretation by using at least two researchers for coding (Neuendorf, 2002). In our study, two researchers with experience in gaming and climate change communication participated in the coding and analysis of games. Both researchers played the complete sample of games on separate computers. In complex games, the researchers had to play the game several times to register data in a proper manner. They shared a protocol with guidelines and definitions to fill in an analysis form which contains the criteria vetted through the Delphi method for each game. They marked their responses and observations in different files, which later where combined into a single one after discussions.

The inter-coder reliability shows to what extent different coders agree on the coding of the same material. The analysis of the games demanded the interpretation by the researchers. Keeping in mind that, among other factors, the messages experienced by the player depends on skills and time committed (Ivory, 2006), so this interpretation must always cling to the formal properties of the game. In our case, despite the subjectivity of some of the criteria and the interpretative implications, both researchers agreed on all game features and there was no need to solve discrepancies. Some of the data which are considered more subjective, such as target audience (criterion 8) or communicative purpose (criterion 9), were obtained through the information provided by the producers on the description of the game on the website. Trustworthiness has been proposed in qualitative content analysis as a means of ensuring quality and methodological soundness, and consists of four factors: a) credibility -the extent to which findings are congruent with reality-; b) transferability-the extent to which findings can be applied to other contexts-; c) dependability -the ability of other researchers to repeat the work, if not necessarily to gain the same results-; and d) confirmability -the extent to which the results can be confirmed or corroborated by the reader- (Hardy et al., 2004).

Study sample

Spanish language online games are used in order to test the criteria and to demonstrate their usefulness in examining communication trends and techniques. For that purpose, we conducted an analysis of 15 online climate change games. Here are the steps taken to compile and select the games:

a) Compiling games: a rigorous web search was carried out in the period May-July 2015 through the main search engines, using the following search request: (“video game” OR “online game” OR “educational game” OR “eco-game”) AND (“climate change” OR “global warming” OR “sustainability” or “environment”), in Spanish.

b) Selecting games: there was a pre-selection stage and a final selection stage, where researchers interacted with the games to confirm that the required selection criteria were present. In order to identify our sample of online climate change games produced in Spain, the following requirements were taken into account:
   - that they are produced in Spain (country chosen as a case study);
   - that they are hosted on a web platform, played over the Internet (our study focuses on online games, for their distinct features as a digital tool, popularity and generalized use among youth, and possibility to be used by teachers at computer laboratories at their schools);
   - that they are free of charge (which increases the possibilities that they will be used and accessed by teachers and teenagers with lower economical resources for these purposes);
   - that they have communicative and educational objectives and a focus on climate change-related issues;
   - that they seem aimed at an adolescent audience of 12+ (our study focuses on strategies towards youth, who have different and more developed cognitive processes than children, allowing us also to target a specific segment of the population as suggested by social marketing for the design of environmental communication efforts).

Games that were excluded from the study were therefore commercial games, those that are only available through a software download or mobile applications (7 games), those whose website links were broken or not available by the time this research was initiated (10 games), games in Spanish produced by a foreign institution (17 games), and games aimed at children or primary education (11 games). Attending to the criteria described above, we have identified a total of 15 games, including online ability/puzzle games, quizzes, online board games, arcade games, action/adventure games, and simulations (Table 2). These games also appear on Spanish Government websites (e.g. National Center for Environmental Education) and on blogs from docents and educational institutions as recommended games.

Game title	**URL and location on web**	**App**	**Language(s)**	**Producer**	**Brief description**
Actúa con tu consumo / *Act on your consumption*	http://consumo.greenpeace.es/ (independent website)	No	Spanish	Greenpeace España	Diverse mini-games, tests and activities that promote critical and responsible consumption, which encourage the player to reflect on the impact of our actions on the environment.
Alerta CO2 / *CO2 Alert*	http://www.accionatura.org/jocAlertaCO2/index.html (located on a section on producer´s website)	No	Catalan	Acción Natura	The player finds diverse mini-games in a virtual city that is getting more or less polluted depending on the decisions taken; the objective is to create awareness of CO2 emissions
Climántica	http://xogo.climantica.org/?locale=es (independent website)	No	Spanish, Galician and English	Xunta de Galicia	Simulation game where the player has to create and manage a sustainable territory, planning actions in a strategic way and being aware of causes and consequences of climate change
Controla / *Control*	http://www.ree.es/es/educaree/juego-controla (located on a section on producer´s website)	No	Spanish	Red Eléctrica Española (REE)	Electric control simulator involving various methods of generation, where the aim is to maintain the electricity supply while addressing issues such as global warming

De primero, reciclaje / *Recycling first*	http://www.reciclaenvases.com/Telerecicla/Telerecicla.php?GameID=2 (located on a section on producer´s website)	No	Spanish	Ecoembes	Interactive and puzzle/skill game where the player has to find all the objects on a list and throw them in their correct container under time pressure
El juego de la separación en casa / *The home sorting game*	http://www.cogersa.es/metaspace/portal/14498/22102 (located on a section on producer´s website)	No	Spanish	Consorcio para la Gestión de los Residuos Sólidos de Asturias (COGERSA)	Puzzle/skill game to learn about the correct use of containers and the importance of waste sorting at home, where the player needs to decide on the correct container
Eneragen, el juego de la energía / *Eneragen, the energy game*	https://www.agenciaandaluzadelaenergia.es/multimedia/eneragen/selectorSD/index.html (located on a section on producer´s website)	No	Spanish	Asociación de Agencias Españolas de Gestión de energía (Eneragen)	Adventure game aimed at raising awareness of efficient energy usage and the use of renewable energies in order to promote sustainable development
Fluvi y el ciclo del agua / *Fluvi and the water cycle*	http://www.expozaragoza2008.es/juegofluvi/ (located on a section on producer´s website)	No	Spanish	Expo Zaragoza 2008	Platform game with three levels where the player has to help Fluvi to save rivers from being polluted, helping him to keep them clean, pick up garbage and control the functioning of a factory
Game sostenibilidad / *Sustainability Game*	http://www.sustainabilitygame.iberdrola.com/ (independent website)	Yes	Spanish and English	Iberdrola	Board game where the players have to respond to questions related to climate change, energy efficiency and clean energies. It is focused on Iberdrola's initiatives around the world
Isla 100% / *Island 100%*	http://proyectoislarenovable.iter.es/el-juego/ (independent website)	Yes	Spanish	Instituto Tecnológico y de Energías Renovables (ITER) + Agencia Insular de Energía de Tenerife (AIET)	Simulation game based on real situations, where the player has to make environmental, technical and economic decisions on an island that depends on fossil fuels, with the aim of achieving the largest proportion of clean energy
Misión posible, salvar el planeta / *Mission possible, save the planet*	http://www.cruzroja.es/juego_cambio_climatico/ (located on a section on producer´s website)	No	Spanish	Cruz Roja Española	Players become ecological superheroes who fight against the uncontrollable emission of greenhouse gases that contribute to climate change into the atmosphere, by completing several mini-games and tests
My Green Energy Planet	http://www.wwf-spainsites.com/mygreenenergyplanet/ (independent website)	No	Spanish	Fundación AXA + WWF España	Simulation game created to raise awareness and change the energy model to mitigate the effects of climate change. To do so, the player has to convert a city into a sustainable place
Multijuegos forestales / *Forestry multigames*	http://www.edufores.com/ (located on a section on producer´s website)	No	Spanish	Edufores	A board game with different mini-games where players have to increase their knowledge and awareness of forestry and environmental issues while riding their virtual bike, with the final aim of replanting a forest
Oca de la bioenergía / *Bioenergy goose game*	http://www.energiaymedioambiente.com/final/cesefor.html (independent website)	No	Spanish	CESEFOR, Junta Castilla y León	Board game with questions and problem-solving activities to raise awareness of energy saving and respect for the environment
Todo un mundo de energía / *A whole world of energy*	http://www.endesaeduca.com/Endesa_educa/ (independent website)	No	Spanish and English	Endesa	Mini-games on energy and its connection to the greenhouse effect and climate change

Table 2. Spanish Online Climate Change Games That Were Analyzed.

4.4.4. **Findings from the analysis**

In this section, we present the findings from the analysis of Spanish games categorized into the four dimensions - identification, narrative, contents, gameplay- and following the same order of the criteria exposed in Table 1.

Identification

Our case study focuses on free of charge games targeting youth (12+) that are available online and have been produced in Spain. In order take a communicative approach to analyzing the features of a game, it is important to look at the transmitter of the message. NGOs occupy the first place in the ranking (33.3%), followed by the private sector (26.7%), and finally public bodies. Therefore, a third of the games in our sample is produced by NGOs. Examples of NGOs include international and well known organizations, such as Greenpeace, Red Cross and WWF; as for examples of the private sector, we find electrical and insurance companies. Results also reveal partnerships between different types of actors in producing the game. For example, the game *Island 100%* is produced by a research center in cooperation with a local government agency.

Other important feature of the analyzed games is language: three of the producers have decided to have the game also available in English, while two of them have the games in Galician and Catalan, languages that have official regional status in Spain.

Because the lines between one communicative purpose and another can be blurred, and they are usually combined, the researchers decided to count the percentage of cases rather than categorizing one game into only one purpose. Table 3 reports that most of the cases aim at providing some basic knowledge on climate change and related issues, developing familiarity with the topic (86.7%). Raising awareness of causes and consequences can be seen in 53.3% of the games analyzed. This purpose is revealed for instance through the type of questions posed to the player in a quiz format (e.g. *CO2 Alert*) or the type of challenges presented in a skill/puzzle game, such as relating the images of causes/consequences (e.g. *Mission possible, save the planet*). A large number of games (73.3% of the cases) focus on promoting a change in attitude and behavior (e.g. *The home sorting game*), and to a lesser extent, we find that 26.7% of the cases stimulate the development of solutions and ideas through creativity (e.g. *Act on your consumption).*

	N	% of cases
Developing familiarity with the topic	13	86.7
Promoting a change in attitudes and behavior	11	73.3
Raising awareness of causes and consequences	8	53.3
Stimulating the development of ideas and solutions	4	26.7

Table 3. Types of Communicative Purposes.

Narrative

In this section, we look at the narrative and fictional context elements, including storylines, story structure, character depiction, representation of the environment and spatial and temporal dimensions. First of all, the results of our study show that the relevance of narrative in the analyzed games is mostly high (40%) and medium (40%). This happens especially in arcade games, adventure/action games and simulations. In

simulations, it is shown how narratives offer the player a range of possibilities at the same time, and it is the players themselves who decide in what order to establish them. Storytelling has been suggested as a key strategy for enhancing attention and engagement: it makes climate impacts and solutions more real, it influences people's beliefs because they shift the frames of reference for emotional and cognitive processes, and it increases people´s capacity for empathy because it can connect with values and social identities (Mar & Oatley, 2008; Strange, 2002).

The findings on narrative reveal that global storylines are very diverse; however, it is noticeable that in the majority of the cases (9 out of 15 cases), the players take on the role of an ordinary citizen who has to take sustainable decisions in their daily lives, such as saving energy and water, recycling, buying ecological food, etc. (e.g. *Bioenergy goose game; Recycling first; Forestry multi-games*). In other cases, the player is a mayor who has to create a sustainable territory, reducing CO2 emissions and keeping the population happy (e.g. *Climántica*); or a superhero who has to save the world from greenhouse emissions, reducing their impact on the Earth (e.g. *Mission possible, save the planet).* Story structures of our sample of games are both lineal (a single endpoint) and multi-linear (several endpoints); there is not a game that provides the players with unclearly defined aims, as is the case with *The Sims*. Some of the games make use of narrators in their stories, usually animals (e.g. a monkey in *Eneragen*) or fantasy creatures (e.g. an elf in *Forestry multigames*), and basically all of them tend to provide a better description of the environments than of the characters.

In addition, 73.3% of the scenarios are fictitious, while 26.7% are real. Examples of real scenarios mentioned in the stories of the games include: Spanish islands, Andes, the Caribbean Sea or the desert in Africa. The stories can also be set on different scales. The local scale refers to decisions taken by private households at their own homes or in the context of a virtual city. The majority of games that were analyzed focus mainly on this local scale (73.3%). They mostly consider individual or community decisions to reduce greenhouse gas emissions, aiming to draw connections between climate change and everyday individual experience and decision-making. A smaller proportion of games (13.3%) are set on a national scale, followed by global (6.7%) and a combination of different scales (6.7%). Using a local perspective is therefore one of the tendencies observed, involving a general preference towards portraying an ordinary citizen and focusing on the local scale.

If we look at the "time" dimension of the stories, the results show that the majority of the games are focused on the present (66.6%), followed by the combination of present and future (26.7%), and a minority focus only on the future (6.7%); however, these findings must be taken with caution since the in-game timelines are blurred. A combination of present and future settings is particularly common in simulation games. For instance, the game *Climántica* is set in the year 2015 at the beginning of the game and time passes until the year 2034.

Contents

Since language is never neutral, the first step to start analyzing the messages transmitted through texts, audio, and images in the games is to consider the creators' preferred terms: climate change or global warming? The majority of the games use the term climate change (60%), while the minority chose global warming (6.7%). Another 33.3%

of the games do not mention any of these terms, mostly because their main topic is not the phenomenon of climate change itself but cross-over issues such as energy efficiency, waste management or consumption. This case study shows therefore a preference among game creators for the term "climate change" over "global warming". In fact, the term "climate change" is predominant in the scientific discourse, and it is ever more visible in traditional media (Boykoff, 2007). Based on British journalist Steven Poole's book *Unspeak* (Poole, 2006), which investigates the manipulative power of language, climate change is a "less threatening" way of saying global warming and "less obviously" related to the oil industry.

A majority of games (66.7%) have chosen to explicitly define certain scientific or other concepts related to climate change to facilitate the player's understanding, such as greenhouse effect, renewable energy, etc. The findings also reveal that only 26.7% took advantage of their online format to converge with social networks. For example, in *Act on your consumption* there are links to documentaries like *The Age of Stupidity*, extracts from the press, Facebook and Twitter accounts of Greenpeace and other environmentalist organizations. It is important to note that erroneous beliefs in relation to the concept of climate change (e.g. ozone depletion or acid rain) have not been found, although some of the games integrate different environmental problems and concepts in their contents which can lead to misunderstanding and wrong relations among players. For instance, in the game *Mission possible, save the planet* the player is introduced to the concept of global warming in a word search puzzle mission and then asked to find a hidden word in relation to water pollution, without further receiving contextual information to distinguish both environmental problems.

Mitigation and adaptation are considered the main responses to climate change (UN, 2016). According to our analysis, the main focus in games is mitigation of greenhouse gases: 60% of the games address only this aspect, while 40% of the games address both mitigation and adaptation measures in their messages. We have not found any Spanish game that focuses only on adaptation. We also investigated content-related aspects by looking at the four themes that appear the most in each game. The primary focus in the games is mitigation of greenhouse gases, as outlined above. More specifically, the themes that are used the most are energy (66.7% of cases), followed by waste management (55.3% of cases), and mobility (53.3% of cases). The use of carbon sinks through replanting trees (e.g. *Forestry multi-games*), water saving (e.g. *Fluvi and the water cycle*), and protecting biodiversity (e.g. *Mission possible, save the planet*) are other recurring themes. In the games analyzed, we have found only few references that promote actions such as eating less meat and no references to the politics of climate change decision-making on an international scale have been found.

The games make it clear that human action is the main cause of climate change (60%). Few of them also make reference to natural causes, but always in combination with human activity (6.7%). The rest of the games (33.3%) do not explicitly mention causes, mainly because these games focus on cross-over issues and not on the phenomenon of climate change itself. The consequences of climate change appear in Table 4.

	N	% of cases
Threat to ecosystems	7	46.7
Extreme meteorological events	6	40.0
Temperature increase	6	40.0
Economic	4	26.7
Desertification, drought	3	20.0
Sea level rise	3	20.0
Not applicable	2	13.3
Glacial melting	2	13.3
Health	2	13.3
Social	1	6.7

Table 4. Cases Relating to Climate Change Consequences.

The tone of what is communicated or the author's attitude towards the audience can be as important as the message, and they can be revealed through words and sentence styles. We have analyzed the four tones that appear the most in each game by carefully observing the values and emotions given to messages. According to our research, the most used are pro-action (93.3% of the cases), informative (66.7%) and directness (53.3%). To a lesser extent, games use the following tones: alarmist, encouraging, caring, protest and humorous.

Here are some examples that represent the common message tones:

- Pro-action: "act quickly, your decisions can reduce CO2" (*CO2 Alert*)
- Informative: "the key to save energy is control" *(Eneragen*)
- Directness: "Hi, I'm Eva, a young consumer like you" (*Act on your consumption*)

The findings reveal the use of a positive tone in the games, focusing on providing information on solutions, encouraging action and implying empathy with the player. The games seem to avoid uncertainty and overall sensationalism in their messages. Another aspect to highlight is the occasional use of humor. Appealing to humor (as some of the games do) can be a potential strategy to target young people, while always taking care not to simplify messages too much or give wrong ideas. For instance, one game states: "game accuracy is low, perfect if you're a beginner or chicken!" (*Control*).

Gameplay

Finally, we look at the gameplay dimension and some of the meanings that arise from the game design and its formal structures. First of all, the concept of interactivity implies, among other aspects, intervention in the content on the part of the user (Aparici & Silva, 2012; Grifeu, 2010); 86.3% of the games are characterized as having a medium/high degree of interactivity, providing players power to intervene in the content. In interactive media, the output comes from the input of the users, so they are not passive consumers of information anymore, and instead, they feel a sense of agency.

When looking at the game dynamics, challenge is the most common, followed by ability, discovery and progression. Game dynamics can be further interpreted into mechanics. Our research reveals that 12 out of 15 games clearly involved decision-making mechanisms, and 10 out of 15 games are under time pressure. Therefore challenge, through decision-making and time pressure, is the most common design

strategy. In fact, decision-making under time pressure is considered a key skill to cope with climate change effects (Kennel et al., 2016). Players must take various parameters into account in real time, planning resources in a strategic way, by analyzing and evaluating information received on such important considerations as urban planning, energy or water management.

On the other hand, we observe that a higher number of games opt for competition (33.3% of the cases) rather than cooperation in their design (6.7% of the cases). This can be observed for instance in how winning conditions are being achieved. This can be interpreted as a lack of transmitting a feeling of alliance, collective action and unity in the fight against climate change. Cooperation and collaboration are considered important values to fight climate change, for instance, in the international system where nations must give their consent to be bound by meaningful commitments (Dinar et al., 2015).

In relation to game dynamics and mechanics, we can differentiate among different types of player profiles (Kim, 2012): creator, competitor, explorer and collaborator. According to our analysis, we have found that the most popular player profile is the explorer (46.7%), followed very closely by the competitor (40%). Fewer cases are characteristic of the creator type of player (13.3%), and none of the games seem to fit primarily the collaborator type of player.

Feedback is critical in games to maintain engagement (De By & Hooper, 2013). Results show that most of the games use a mix of positive and negative messages in their feedback system (66.7%). Similarly, our study shows that the majority of games analyzed use an intangible reward system (60%) to reward individual actions. Intangible rewards (e.g. extra points, virtual coins) are awarded by answering a quiz question correctly, making sustainable decisions under time pressure or doing well in the skill games, whether it is by turning the street lights off quickly or by matching up cause and consequence images of climate change. Rewards are considered to act as motivators to take actions, when the right type and magnitude of incentive for a given behavior is provided (Handgraaf et al., 2013); therefore, this game attribute could be valuable to achieve one of the communicative goals of climate change games.

It is also worth mentioning that the lengths of most of the games are less than one hour and that game instructions are available, which makes it easier for them to be implemented by teachers in class. Only two of the games offer the possibility to save the game session to continue their progress in future.

4.4.5. **Discussion and conclusions**

Our research has shown that it is possible to integrate a narratological and a ludological approach and how this combination can be helpful to analyze communication features of available online climate change games in a holistic and integrating manner: focusing on the relationships between game narrative and design, and on the transmission of explicit meanings and implicit values. This study proposes a set of criteria that embraces both approaches and reaches the consensus of a panel of experts. By applying them to a sample of games in a specific country, we have been able to provide an interesting overview of online climate change games, giving us an idea as to what type

of messengers, messages and preferred techniques are behind this innovative communication tools.

The findings from the analysis reveal some positive trends, since they have incorporated the recommendations given by scholars like Sheppard (2012) on how to communicate climate change: (1) make it local –to avoid psychological distance-, (2) make it visual – to make climate change more real and memorable-, and (3) make it connected – to provide a sense of agency-. First of all, the majority of the games provide a local discourse. There is a general preference towards portraying an ordinary citizen and focusing on local scenarios, in which players must make decisions at home or within their communities to reduce carbon emissions. Secondly, players are able to see through visual representations the implications of climate change, absorbing information more readily and simulating unfamiliar circumstances that aren't possible in real life. Most games allow players to make decisions in the present and then travel into the future, where they can see the consequences of their choices, an advantage that has been corroborated by similar studies (Schroth et al., 2014). Thirdly, many games present a positive discourse, not only through stories and messages that focus on solutions, but also through the game design. Positive and immediate feedback is critical to maintain engagement and rewards are seen as incentives to take actions (Handgraaf et al., 2013).

As mentioned in the literature review, the communicative goals of online climate change games are: making players aware of the challenges associated with climate change, providing understanding of the issue, and encouraging players to take actions. According to different authors, focusing on visible solutions, as well as localized stories and positivism, can be considered a strategy to achieve these communicative goals (Maibach et al. 2010; Moser & Dilling, 2011; Sheppard, 2012; Schroth et al., 2014).

It is out of the scope of this study to test the effectiveness of the selected games in pursuing their communicative goals, however, we can mention that there is limited empirical evidence currently available to prove effectiveness of serious games. Some studies have found positive changes in awareness and understanding, although no statistically significant differences between experimental and control group (Van Pelt et al., 2015). In the review carried out by Soekarjo & van Oostendorp (2015), increased knowledge of players was found in five of the sixty games reviewed, change in attitude after playing was also found in five games, and change in behavior in three games.

The findings from our analysis also reveal some areas that could be improved. Games could, for instance, integrate more climate change adaptation contents (just 40% address both mitigation and adaptation measures in our sample). Other studies have revealed similar findings (Reckien & Eisenack, 2013). This is important for countries like Spain, where there is a risk of desertification due to increasing temperatures and a reduction in precipitation, and therefore, a need for adopting adaptation measures (Martínez-Valderrama et al., 2016). In addition to this, we believe that games that address climate change should avoid addressing other environmental concepts such as depletion zone or acid rain in order to avoid misconceptions and confusion among players; incorporating a team of scientists might help to achieve this purpose and ensure scientific accuracy.

Taking more advantage of their online format to converge with social networks like Facebook or Twitter could be another strategy to move forward (less than 30% of the analyzed games integrate social media in their platforms). For instance, the use of social

media allows gamers to post their gaming scores, enhancing gameplay experience and increasing the likelihood to return to the website (CRED, 2014). This not only can increase the chance of developing awareness of the issue, but it also can provide social incentive for action, as people are often highly motivated to follow the behavior of their peers (Ajzen, 2002). Finally, most games in our sample encourage individual skills development, so a greater integration of cooperation mechanisms in their structure and design (portraying the collaborator player profile) would be highly recommended to call for collective action and enhance efficacy. In this sense, the field of online climate change games could have a closer look at massively multiplayer online games (MMOGs), which enable players not only to compete but also to cooperate with each other, and sometimes to interact meaningfully with other players around the world (Wagner, 2008).

This study has some limitations, including the small sample of games, the limited game space as a result of the selection requirements, the decrease in number of experts during the Delphi process, and the difficulty to apply a systematic content analysis. We would like to recommend designers to take into account the points highlighted above and academics to make use of a similar methodology and criteria to those proposed in this paper to analyze the communicative elements of online climate change games produced in other countries and in other languages to be able to make comparisons and to draw conclusions at a global level. A follow-up research effort could also be conducted of English-language games, as they constitute another large component of the game space. Other questions emerging from this study are related to the impacts of these games on youth, including how players receive the messages and if there is any long-term effect in terms of behavior change. Complementary studies on the effectiveness of these games should be carried out in order to confirm the potential of online climate change games to successfully communicate climate change to young people.

4.4.6. **References**

Aguaded-Gómez, I. (2011). Niños y adolescentes: nuevas generaciones interactivas. *Comunicar 36*(XVIII), 7-8. doi: 10.3916/C36-2011-01-01

Ajzen, I. (2002). Perceived control, self-efficacy, locus of control, and the theory of planned behavior. *Journal of Applied Social Psychology, 32*, 107-122. doi:10.1111/j.1559-1816.2002.tb00236.x

Aparici, R. & Silva, M. (2012). Pedagogía de la Interactividad. *Comunicar, 38*(XIX), 51-58. doi: 10.3916/C38-2012-02-05

Astigarraga, E. (2008). *El método Delphi*. San Sebastián: Universidad Deusto.

Bloom, B. S. (1956). *Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain*. New York: David McKay Co Inc.

Bofferding, L. & Kloser, M. (2015). Middle and high school students' conceptions of climate change mitigation and adaptation strategies. *Environmental Education Research 21*(2), 275–294. doi: 10.1080/13504622.2014.888401

Boykoff, M. T. (2007). Flogging a dead norm? Newspaper coverage of anthropogenic climate change in the United States and United Kingdom from 2003 to 2006. *Area*, *39*(4), 470–481. doi: 10.1111/j.1475-4762.2007.00769.x

CRED- Center for Research on Environmental Decisions and ecoAmerica (2014). *Connecting on Climate: A Guide to Effective Climate Change Communication*. New York and Washington D.C.: CRED.

Cooper, C. B. (2011). Media Literacy as a Key Strategy towards Improving Public Acceptance of Climate Change Science. *BioScience, 61*(3), 231-237. doi: 10.1525/bio.2011.61.3.8 PubMed

De By, P. & Hooper, J. (2013). Key Attributes of Engagement in a Gamified Learning Environment. In *Proceedings 30th ascilite conference* (pp. 1-4). Sydney: Macquarie University.

DEV (2015). *Libro blanco del desarrollo español de videojuegos*. Madrid: DEV.

Díaz-Nosty, B. (2013). Aproximación a la construcción interdisciplinar y de un Nuevo paradigma. Comunicación, cambio climático y crisis sistemática. *Razón y Palabra*, *84,* 99-119. doi: 10.4185/RLCS-64-2009-808-99-119

Dinar, S., Katz, D., De Stefano, L., & Blankespoor, B. (2015). Climate change, conflict, and cooperation: Global analysis of the effectiveness of international river treaties in addressing water variability. *Politic Geography, 45*, 55–66.

Dudo, A., Cicchirillo, V., Atkinson, L. & Marx, S. (2014). Portrayals of Technoscience in Video Games: a potential avenue for informal science learning. *Science Communication, 36*(2), 219-247. doi: 10.1177/1075547013520240

Egenfeldt-Nielsen, S., Smith, J.H. & Pajares-Tosca, S. (2008). *Understanding videogames*. Nueva York: Routledge.

Fielding, K. & Head, B.W. (2012). Determinants of young Australians' environmental actions: the role of responsibility attributions, locus of control, knowledge and attitudes. *Environmental Education Research*, *18*(2), 171-186. doi: 10.1080/13504622.2011.592936

Frasca, G. (2007). *Play the Message: Play, Game and video game Rhetoric* (Unpublished doctoral dissertation). IT University of Copenhagen.

Gee, J.P. (2004). *Lo que nos enseñan los videojuegos sobre el aprendizaje y el alfabetismo.* Archidona: Aljibe.

Gombrich, E. H. (2004). *El sentido del orden*. Madrid: Debate.

Gozálvez-Pérez, V., González-Fernández, N., & Caldeiro-Pedreira, MC (2014). La competencia mediática del profesorado: un instrumento para su evaluación*. Revista Electrónica de Investigación Educativa, 16*(3).

Grifeu, A. (2010). *El documental interactivo. Evolución, caracterización y perspectivas de desarrollo*. Barcelona: Editorial UOC.

Handgraaf, M.J., Van Lidth de Jeude, M.A., & Appelt, K.C. (2013). Public praise vs. private pay: Effects of rewards on energy conservation in the workplace. *Ecological Economics, 86*, 86–92.

Hardy, C., Harley, B. & Phillips, R. (2004). Discourse analysis and content analysis: two solitudes? In: Y. Herrera & B. Braumoeller (Eds.), *Symposium: Discourse and Content Analysis. Qualitative Methods*: *Newsletter of the American Political Science Association Organized Section on Qualitative Methods*, 2 (pp. 19–22).

Huizinga, J. (1938). *Homo Ludens: el elemento lúdico de la cultura*. Madrid: Alianza.

Ivory, J. D. (2006). Still a man's game: Gender representation in online reviews of video games. *Mass Communication & Society, 9*, 103-114.

Juul, J. (2005). *Half-Real: video games between real rules and fictional worlds.* Cambridge, MA: The MIT Press.

Katsaliaki, K., & Mustafee, N. (2014). Edutainment for Sustainable Development: A survey of Games in the Field. *Simulation & Gaming, 1*(26), 1-26. doi: 10.1177/1046878114552166

Kennel, C.F., Briggs, S., & Victor, D. (2016). Making climate science more relevant. *Science, 354*(6311), 421-422. doi: 10.1126/science.aag3248

Kim, A. J. (2012). *Social engagement: who´s playing? How do they like to engage?* Retrieved from http://goo.gl/BFTnhh

Lacasa, P. (2011). *Los videojuegos. Aprender en mundos reales y virtuales.* Madrid: Ed. Morata.

León, B. et al. (2013). *El periodismo ante el cambio climático. Nuevas perspectivas y retos.* Barcelona*:* UOC.

Liarakou, G., Sakka, E., Gavrilakis, C., & Tsolakidis, C (2012). Evaluation of serious games, as a tool for education for sustainable development. *EURODL (Special issue),* 96-110.

Linstone, H.A., & Turoff, M. (1975). Introduction. In H. A. Linstone, y M. Turoff (Eds.), *The Delphi method: Techniques and applications,* Reading, MA: Addison-Wesley Publishing Company (pp. 3-12).

Liu, S., & Ding, W. (2009). An approach to Evaluation Component Design in Building Serious Games. In M. Chang, R. Kuo, G.-D. Chen & M. Hiroshe (Eds.), *Edutainment ´09 Proceedings of 4th International Conference on E-learning and Games: learning by playing* (pp. 141-148). Berlin: Springer.

Maibach, E., Nisbet, M., Baldwin, P., Akerlof, K., & Diao, G. (2010). Reframing Climate Change as a Public Health Issue: An Exploratory Study of Public Reactions. *BMC Public Health 10*: 299–309. doi: 10.1186/1471-2458-10-299

Mar, R.A., & Oatley, K. (2008). The function of fiction is the abstraction and simulation of social experience. *Perspectives on Psychological Science, 3*(3), 173–192.

Martí-Parreño, J., Méndez-Ibáñez, E., Giménez-Fita, E., & Queiro-Ameijeiras, C. (2015). El uso de la gamificación en la educación superior: propuesta de una ficha de análisis ludológico-narratológico. In M.A Ruiz Rosillo (Ed.), *XII Jornadas Internacionales de Innovación Universitaria Educar para transformar: Aprendizaje experiencial* (pp. 103-111). Madrid: Universidad Europea de Madrid.

Martínez-Valderrama, J., Ibáñez, J., Del Barrio, G., Sanjuán, M.E., Alcalá, F.J., Martínez-Vicente, S., Ruiz, A. & Puidgefábregas, J. (2016). Present and future of desertification in Spain: Implementation of a surveillance system to prevent land degradation. *Science of the Total Environment, 563-564*, 169-178. doi:10.1016/j.scitotenv.2016.04.065

Meira-Cartea, P.A. (2008). *Comunicar el cambio climático. Escenario social y líneas de actuación.* Madrid: Ministerio de Medio Ambiente y Medio Rural y Marino-Organismo Autónomo de Parques Nacionales.

Mendler de Suarez, J., Suarez, P. & Bachofen, C. (2012). *Games for a New Climate: Experiencing the Complexity of Future Risks. Boston:* Boston Univ., The Frederick S. Pardee Center for the Study of the Longer-Range Future.

Merkl-Davies, D.M. & Koller, V. (2012). 'Metaphoring' people out of this world: a critical discourse analysis of a chairman's statement of a UK defence firms. *Accounting Forum, 36*(3), 178–193.

Mitgutsch, K. & Alvarado, N. (2012). Purposeful by Design? A serious game design assessment framework. *Proceedings of the International Conference on the Foundations of Digital Games* (pp. 121-128). New York: ACM.

Moser, S.C. (2010). Communicating Climate Change: History, Challenges, Process and Future Directions. *WIREs Climate Change, 1*, 31-53. doi: 10.1002/wcc.011

Moser, S.C., & Dilling, L. (2011). Communicating Climate Change: Closing the Science-Action Gap. In J.S. Dryzek, R.B. Norgaard, & D. Schlosberg (Eds.), *Oxford Handbook of Climate Change and Society* (pp. 161-174). Oxford: Oxford University Press.

Murray, J. (1999). Hamlet *on the Holodeck.* Cambridge, MA: The MIT Press.

Neuendorf, K. (2002). *The Content Analysis Guidebook.* London: Sage Publ.

Nisbet, M., & Scheufele. D. (2009). What's Next for Science Communication? Promising Directions and Lingering Distractions. *American Journal of Botany 96*, 1767–1778. doi: 10.3732/ajb.0900041

Partridge, E. (2008). From ambivalence to activism: Young people's environmental views and actions. *Youth Studies Australia, 2.* 18–25.

Pérez-Latorre, O. (2010). *Análisis de la significación del videojuego. Fundamentos teóricos del juego, el mundo narrativo y la enunciación interactiva como perspectivas de estudio del discurso* (Unpublished doctoral dissertation). Universitat Pompeu Fabra, Departament de Comunicació, Barcelona.

Piñuel-Raigada, J.L. & Teso-Alonso, G. (2012). Los temas de referencia abordados en las noticias de los informativos televisivos en España con ocasión de las cumbres del Cambio Climático en Cancún y Durban. In J.L. Piñuel-Raigada et al. (Eds), *Comunicación, controversias e incertidumbres frente al consenso científico acerca del cambio climático*. Cuadernos Artesanos de Latina, 30.

Poole, S. (2006). *Unspeak: words are weapons: the language of everyday deception*. London: Little Brown.

Pozo-Llorente, M.T., Gutiérrez-Pérez, J. & Rodríguez-Sabiote, C. (2007). El uso del método Delphi en la definición de los criterios para una formación de calidad en animación sociocultural y tiempo libre, *Revista de Investigación Educativa*, *25*(2), 351-366.

Prensky, M. (2001). Digital natives, digital immigrants. *On The Horizon*, *9*(5), 1-6. doi:10748120110424816

Reckien, D., & Eisenack K. (2013). Climate Change Gaming on Board and Screen: A review. *Simulation and Gaming, 44*(2-3), 253-271. doi:10.1177/1046878113480867

Reig, R. (2010). Condicionantes estructurales del trabajo del periodista: las causas de una sociedad desinformada. *Global Media Journal, 7*(14), 39-59.

Rodríguez-Hoyos, C. & João Gomes, M. (2013). Videojuegos y educación: una visión panorámica de las investigaciones desarrolladas a nivel internacional. *Revista Profesorado, 17*(2), 480-494.

Scapolo, F. & Miles, I. (2006). Eliciting expert´s knowledge: A comparison of two methods. *Technological Forecasting and Social Change, 73*, 670-704.

Schmierbach, M. (2009). Content analysis of video games: Challenges and potential solutions. *Communication Methods and Measures, 3*, 147-172.

Schroth, O., Angel, J., Sheppard, S. & Dulic, A. (2014). Visual Climate Change Communication: From Iconography to Locally Framed 3D Visualization. *Environmental Communication, 8,* 413–432. doi: 10.1080/17524032.2014.906478

Shaker, N., Togelius, J. & Nelson M.J. (2016). *Procedural Content Generation in Games: A Textbook and an Overview of Current Research*. New York: Springer.

Sheppard, S.R.J. (2012). *Visualizing climate change: A guide to visual communication of climate change and developing local solutions*. Abingdon, Oxon: Routledge.

Strange, J.J. (2002). How fictional tales wag real-world beliefs: Models and mechanisms of fictional influence. In M.C. Green, J.J. Strange, & T.C. Brock (Eds.), *Narrative Impact: Social and Cognitive Foundations* (pp. 263–286). Mahwah, NJ: Erlbaum.

Taylor, T.L. (2006). *Playing between worlds: exploring on-line game culture.* Cambridge, London: MIT Press.

Tejeiro, R. & Pelegrina, M. (2003). *Los videojuegos: qué son y cómo nos afectan*. Barcelona: Ariel.

Van Pelt, S.C. et al. (2015). Communicating climate (change) uncertainties: simulation games as boundary objects. *Environmental Science & Policy, 45,* 41-52. doi: 10.1016/j.envsci.2014.09.004

Wagner, M.D. (2008). *Massively Multiplayer Online Role-Playing Games As Constructivist Learning Environments* (Unpublished doctoral dissertation). Walden University.

Werbach, K. & Hunter, D. (2012). *The Gamification Toolkit*. Pennsylvania: Wharton Digital Press.

Wu, J. & Lee, J. (2015). Climate change games as tools for educational and engagement. *Nature Climate Change, 5*, 413-418. doi: 10.1038/NCLIMATE2566

4.5. Gaming climate change: assessing online climate change games targeting youth produced in Spanish

Article 5: Ouariachi, T., Olvera-Lobo, M.D., & Gutiérrez-Pérez, J. (2017). "Gaming climate change: assessing online climate change games targeting youth produced in Spanish". *Procedia - Social and Behavioral Sciences, 237* (21), 1053-1060. DOI: 10.1016/j.sbspro.2017.02.154

In search of innovative approaches to raise climate change awareness among digital natives, online and serious games are gaining currency as new platforms for communication, education and social change. Thanks to their interactivity and immersive narrative, games have capacity to convey to young people the problems that they will be facing in the future and enable them to experience these problems directly through the game. In addition, online games can offer the possibility to be implemented in educational contexts as a didactic tool for teachers. This study aims a) to present a checklist with validated evaluation criteria identified through the Delphi method; and b) to conduct a qualitative evaluation of communicative and educative elements of a sample of 24 online climate change games targeting youth and produced in Spanish. Our findings suggest that the games evaluated seem to be on the right path, making the topic of climate change local, visual and connected, although there is still room for improvement in terms of contents, gameplay and didactics.

4.5.1. Introduction

The commitment of the new generation is crucial for changing the world and critical for avoiding the worst impacts of global challenges such as climate change, but surveys show that awareness of the issue is still limited and a notable lack of commitment to adopting measures for mitigating and adapting to climate change can be seen (Bofferding & Kloser, 2014; Meira et al., 2013). Scholars acknowledge the limitations of conventional media and traditional education programs in delivering information, such as the one-way transmission of messages, the lack of contextualization, and the negative and alarmist tone of the content (Aparici & Silva, 2012; León et al., 2013; Díaz-Nosti, 2013; Moser, 2010; Reig, 2013) and call for innovative strategies to engage youth in climate change. Taking into consideration the communicative paradigm of the so-called "interactive generation" (Aguaded-Gómez, 2011) or "digital natives" (Prensky, 2001) and the hours they spend playing online games, it would be logical to pay more attention to these tools. Videogames in general, and online games in particular, can offer active engagement and experiential learning, transforming passive consumers of information into active players who absorb new information more readily; simulate unfamiliar circumstances that aren't possible in real life, liking decisions to consequences; and inspire out-of-the-box and critical thinking.

When talking about *online climate change games* we are focusing on games available on the Internet specifically themed around climate change and/or topics related to this phenomenon, with communicative and educational purposes, which does not exclude that they can involve some degree of fun and entertainment. These types of videogames are then considered as *serious games,* understood as games intended to fulfill a purpose, to convey ideas and values and sometimes at persuading the players (Frasca, 2007). They have experienced most of the progress in the last 10 years (Reckien & Eisenack, 2013). So what types of online games tackling climate change are out there? What are their communicative and educational characteristics?
To our knowledge, not much empirical research is available to date researching their educommunicative nature, and the existing studies mostly focused on English-speaking

games ignoring other languages such as Spanish (Katsaliaki and Mustafee, 2014; Reckien & Eisenack, 2013; Wu & Lee, 2015). Therefore, the main objective is to assess the communicative and educative elements of online climate change games produced in Spanish. A secondary objective is to offer a checklist with validated evaluation criteria to judge these games, which can help not only to understand more their nature and reveal explicit-implicit meanings, but also to teachers when deciding appropriate games as pedagogical resources.

4.5.2. Methodology

The research presented here is characterized as interdisciplinary, exploratory and evaluative. Our qualitative study makes use of the Delphi method to develop a checklist with validated evaluation criteria, and of the content analysis, narratology and ludology to evaluate a sample of games produced in Spanish. We describe below the steps and research methods carried out in this study.

Checklist with validated evaluation criteria

In order to develop criteria that reach consensus among experts on their relevance and usefulness for evaluating communicative and educative elements in online games focusing on climate change contents, we made use of the Delphi method, a structured and interactive process to collect opinions that establish consensus, based on the experiences and judgments of experts (Scapolo & Miles, 2006). In our case, a total of thirteen experts from Spain and abroad participated in the study. The experts were chosen for their theoretical and practical knowledge, motivation to participate in the study and feasibility of contact; their areas of expertise are communication, education, games and climate change. The technique consisted in three consulting rounds: in the first round, an open question was sent to the experts to assess the relevance and usefulness of preliminary dimensions (categories of evaluation) and criteria (indicators of evaluation), identified through an extensive literature review and pre-selected for their potential to provide useful information from a narratological and ludological point of view, inspired by the "Social Discourse of Videogames Analysis Model" by Pérez-Latorre (2010), which integrates both analysis perspectives. They also propose new dimensions and/or criteria if necessary. The second consulting round consisted of a questionnaire in which experts assessed in ordinal terms (high, medium, low) the relevance and usefulness of the evaluation criteria. The criteria that got a consensus of 90% (high + medium) were selected. In the third and last round, we requested a final assessment of the criteria that did not pass the second phase, confirming whether or not they should remain outside of the final set of criteria.

Dimensions	**Evaluation criteria**
Identification	• game title • URL: *link to the website; and* availability of mobile app • language/s • type of creator: *author behind the creation of the game and type of institution* • communicative purpose: *communicative intentions and objectives of the game* • brief description: *summary according to the genre, objectives and back story*
Narrative	• relevance of narrative: *narrative elements can acquire importance or be irrelevant* • global storyline: *the story in its entirety, the logical or causal succession of the events* • character depiction and role: *characteristics and qualities of the character/avatar* • representation of the environment: *the world in which the character/player develops* • dimension/space/scale: *general context and scale of the scenarios*

	• dimension/time: *period in time that the story spans*
Contents	• term used: *terminology used to describe the phenomenon being studied* • existence of false concepts and misconceptions • explicit use of scientific concepts: *definition of climate change terms* • explicit use of information sources: *the sources of information and data are cited* • convergence with other media or social networks: *links to social networks are included* • message framework: *themes, causes/consequences and tone*
Gameplay	• number of players and type of use: individual or multi-player • player type: *players' profile depending on their interests* • degree of interactivity: *user intervention in the content* • length of playing: *time employed to play the game* • game mission • game dynamics and mechanics: *structure, rules and basic elements* • feedback system: *message that the player receives in light of certain actions* • reward system: *actions that incentivise and the rewards themselves* • availability of game instructions and possibility of saving the game
Didactics	• competences: *knowledge and attitudes that students can reach* • abilities: *mental operations that students can reach* • problem resolution conditions: *type of reasoning to solve problems* • need for previous knowledge • learning curve: *level of learning difficulty* • possibility of group work • accessibility: *availability of the game for students with functional diversity* • interdisciplinarity: *combination of two or more academic disciplines* • availability of didactic guidelines: *document or link with educational information*

Table I. Dimensions and evaluation criteria in the checklist

Study sample

A web search was carried out in the time period August-December 2015 in the main search engines formulating the following search request: ("videogame" OR "online game" OR "educative game" OR "eco-game") AND ("climate change" OR "global warming" OR "sustainability" or "environment"), in Spanish. Particular emphasis was placed on searching climate change-related government and NGO directories, as well as websites specializing in education 2.0 and videogames. In order to identify a sample of online climate change games produced in Spanish, the following requirements were taken into account: that they are hosted on a web platform and are free to access; that they are played over the Internet; that they have communicative and educational objectives; that the focus of the storyline is climate change or related aspects such as recycling, energy efficiency, sustainability; and that they are aimed at an adolescent audience (12+). In addition, snowball and interviews with key users from online videogame communities were also employed to identify the following 24 games: *Actúa con tu consumo* (Greenpeace Spain); *Alerta CO2* (Acción Natura / Generalitat de Catalunya); *Alto a los desastres!* (UN-ISDR); *Climántica* (Xunta de Galicia); *Concurso del Cambio Climático* (European Union); *Controla* (Red Eléctrica Española); *De primero, reciclaje* (Ecoembes); *El juego de la separación en casa* (Consorcio para la Gestión de los Residuos Sólidos de Asturias); *Eneragen, el juego de la energía* (Asociación de Agencias Españolas de Gestión de Energía); *Enercities* (Paladin Studios, ROC Nijmegen, Qeam, LMC, Akademie Klausenhof, KEK, LUV, Agencia de la Energía de Granada/ European Union); *Energy 2020* (Universcience, France TV Éducation, Tralalere / European Union*); Fluvi y el ciclo del agua* (Expo Zaragoza 2008); *Game sostenibilidad* (Iberdrola); *Isla 100%* (Instituto Tecnológico y de Energías Renovables and Agencia Insular de Energía de Tenerife); *Misión posible, salvar el planeta* (Cruz Roja Española); *My Green Energy Planet* (Fundación AXA, WWF Spain); *Multijuegos forestales* (Edufores*); Oca de la bioenergía* (CESEFOR, Junta Castilla y León, Alida Ingeniería del medio SL); *Switch them off* (WWF); *Todo un*

mundo de energía (Endesa); *Vinyl Game* (Vinyl – European Union program); *Water alert* (UNICEF); *Where the rivers meet the sea* (NOAA); *3rd World Farmer* (IT-University of Copenhagen).

Taking into account that the subject matter is videogames, two researchers took part in the coding of the material making use of Table I. Levels, missions and episodes were used as analysis units, similar to scenes in movies or strip-frames in comics. The evaluation therefore encompasses a mix of content analysis, which provides more quantitative information, as well as narratology and ludology, focusing on the relationships between game narrative and design, on the context of the messages, and on the transmission of implicit values and meanings.

4.5.3. Results

In this section we present the results from the evaluation, categorized in each of the dimensions introduced in the checklist, allowing us to assess the communicative and educative elements of online climate change games produced in Spanish.

Identification

First of all, our evaluation have noticed that the majority of games (58,3%) are located in an independent website from the institution, and that only three of them count with a mobile application version. Other language options apart of Spanish include Galician (1 game), Catalonian (2 games) and English together with other languages (10 games). Those games that have been financed by European Union are the ones that offer more languages apart of Spanish and English (e.g. *Enercities; Energy 2020*). Our study distinguishes between various actors as messengers: NGOs occupy the first place in the ranking (25,0%), followed by the private sector (20,8%), and intergovernmental organizations (16,7%). Only one game has been developed by a University or research institution. Results also reveal cooperation between different types of actors in creating and producing games. For instance, *My Green Energy* Planet was developed by an environmental NGO (WWF) and an insurance company (Fundación AXA).

Most of the cases aim to provide some basic knowledge on climate change and related issues, developing familiarity with the topic (79,2%). Raising awareness of causes and consequences can be seen in 58,3% of the games evaluated, and the same percentage applies to promoting a change in attitude and behavior. Raising awareness causes-consequences is revealed for instance through the type of questions posed to the player in a quiz format or the type of challenges presented in a skill/puzzle game, such as relating the images of causes/consequences. To a lesser extent, we find that 41,7% of the cases stimulate the development of solutions and ideas through creativity. This last purpose can be clearly seen in the game *Act on your consumption*, where the character Eva suggests that the player look around and check how many items are made of plastic in order to encourage the player to reflect and think how they can be substituted. She also encourages the player to write down his/her own plans for a sustainable diet and mobility low in CO2.

Narrative

The results of our study show that the relevance of narrative in the games evaluated is mostly medium-high (70,9%). Arcade games, adventure/action games and simulations are the formats that contain more narrative weight. A great example of the narrative weight is *Water Alert*, where young people are engaged in an adventure of strategy and survival aiming to ensure that the people in a drought-challenged village, who are facing the threat of a flood, have water that is safe to drink and a clean and healthy school environment.

The findings on narrative reveal that global storylines are very diverse; however, it is noticeable how in half of the games, the players take on the role of an ordinary citizen who has to take sustainable decisions in their daily lives, such as saving energy and water, recycling, buying ecological food, etc. (e.g. *Actúa con tu consumo; De primero, reciclaje; Energy 2020*). In 20,8% of the games, the player takes the role of a major: in *Climántica*, the major has to create a sustainable territory to reduce CO2 emissions and keep population happy, while in *Alto a los desastres!* the major has to create a safe territory to reduce the risk of disasters. Other roles include being a superhero that has to save the world from greenhouse emissions (e.g. *Misión possible, salvar el planeta)* or an African farmer who manages a farm and has to deal with challenges like drought (e.g. *3rd World Farmer*). Some of the games make use of narrators in their stories, such as animals (e.g. the penguin CLIMI in *Climántica* or a monkey from outer space in *Eneragen*) or fantasy creatures (e.g. an elf in *Multijuegos Forestales*).

Despite the diversity of storylines in the games, all games tend to provide a better description of the environments than of the characters, partly because of the nature of the climate change topic. In *CO2 Alert*, for instance, the players are placed in the fictitious city of Metropolis and they can choose between different scenarios, such as roads, schools or houses, where CO2 emission needs to be reduced. Similarly, in the game *Climántica*, the player decides to leave for a new territory, and can choose between an inland territory, a rugged territory that gives way to the open sea, and a coastal territory. This first option allows the user to place themselves in a meaningful location, thereby adapting communication to the user's own context and interests.

In addition, 66,7% of the scenarios are fictitious, while 33,3% are real (e.g.: Spanish islands, Andes, the Caribbean Sea, Africa). The stories can also be set on different scales. The local scale refers to decisions taken by private households at their own homes or in the context of a virtual city. The majority of games evaluated focus mainly on this scale (70%), followed by a combination between global-national-local (12,5%). If we evaluate the "time" dimension of the stories, the results show that the majority of the games are focused on the present (54,2%). A combination of present and future settings is particularly common in simulation games. For instance, the game *Climántica* is set in the year 2015 at the beginning of the game and time passes until the year 2034. Through this present-future connections, online games try to offer opportunities to convey to young people the problems that they will be facing in the future and enable them to experience them directly through the game.

Since language is never neutral, the first step to start evaluating the messages is to consider the creators' preferred terms to describe the phenomenon. Half of the games use the term "climate change" and just two of the games prefer "global warming". The rest of the games do not mention any of these terms, mostly because their main topic is not the phenomenon of climate change but cross-over issues such as energy efficiency, waste management or consumption. A majority of games (58,3%) have chosen to explicitly define certain scientific or other concepts related to climate change to facilitate the player's understanding, such as greenhouse effect, renewable energy, etc. However, only eight cases provide the source of the information, and seven took advantage of their online format to converge with social networks. For example, in *Actúa con tu consumo* there are links to documentaries like *The Age of Stupidity*, extracts from the press, Facebook and Twitter accounts of Greenpeace and other ecologist organizations. *EnerCities* can be played on Facebook, encouraging the competition among players. We have also noticed that false concepts or misconceptions have not been found, although some of the games integrate other environmental problems and concepts such as acid rain or ozone depletion which can lead to misunderstanding and wrong relations among players.

Mitigation and adaptation are considered the main responses to climate change by the UN. According to our evaluation, the main focus in games is mitigation of greenhouse gases: 58,3% of the games address only this aspect, while 29,2% of the games address both mitigation and adaptation measures in their messages, and 12,5% address mainly adaptation, such as *Alto a los desastres!, Water Alert* or *3r World Farmer*. We also investigated content-related aspects by looking at the four themes that appear the most in each game. The games address a variety of climate-related themes, but the primary focus is energy (58,3% of cases), followed by mobility (45,8% of cases) and waste management (41,7% of cases). Other interesting main topics are the use of carbon sinks through replanting trees (e.g. *Multijuegos forestales*), water saving (e.g. *Fluvi y el ciclo del agua*), protecting biodiversity (e.g. *Where the rivers meet the sea*), and farming (e.g. *3rd World Farmer*).

The games make it clear that human action is the main cause of climate change. Half of the games explicitly expressed it, while few of them make reference to natural causes in combination with human activity (16,7%). The rest of the games (33,3%) do not explicitly mention causes, mainly because these games focus on cross-cutting issues and not to the phenomenon of climate change itself. As for the consequences of climate change, the games highlight extreme meteorological events, threat to ecosystems, raise of temperatures, health and economic impacts.

The tone of what is communicated or the author's attitude towards the audience can be revealed through words and sentence styles. We have analyzed the four tones that appear the most in each game. According to our research, the most used are pro-action (91,7% of the cases), informative (75,0%) and directness (45,8%). Examples for pro-action tone include "*Many futures are possible, do you dare to change the world? Take decisions today that will lead to a better tomorrow*" (*Energy 2020*); and for directness, "*Hi, I'm Eva, a young consumer like you*" (*Actúa con tu consumo*). The findings reveal the use of a positive tone in the games, focusing on providing information on solutions, encouraging action and implying empathy with the player. To a lesser extent, other

tones chosen by the authors are alarmist, encouraging, and caring. Another aspect to highlight is the occasional use of humor, which can be a potential strategy to target young people (e.g.: "*Game accuracy is low, perfect if you're a beginner or chicken!*" in *Controla*).

Gameplay

From a more ludological point of view, we find first of all that the majority of games (58,3%) are characterized as having a high degree of interactivity, providing players great power to intervene in the content. When looking at the game dynamics, challenge is the most common, followed by progression, discovery, ability, and status, the last one usually supported by rankings and leader boards. Game dynamics can be further interpreted into mechanics. Our research reveals that 20 out of 24 games clearly involved decision-making mechanisms, and 15 out of 10 games are under time pressure, supported mostly by points and levels. This reveals that challenge, through decision-making and time pressure, is the most common design strategy. In fact, decision-making under time pressure is considered a key skill to cope with climate change effects: players must take various parameters into account in real time, planning resources in a strategic way, by analyzing and evaluating information received on such important considerations as urban planning, energy or water management. Looking at the different types of player profiles, we have found out that the most popular player profile is the explorer (33,3%) and competitor (33,3%). Fewer cases are characteristic of the creator type of player (25%) and collaborator (8,3%). The fact that most of games respond to the explorer profile is correlated with the data on number of players and type of use, since the majority of the games are made for one player. Multi-player is mostly observed in board games format.

The individual actions that are carried out in the character/player's story can be accompanied by feedback (evaluation of the actions and their impact). Results show that most of the games use a mix of positive and negative messages in their feedback system (66,7%). Similarly, our study shows that the majority of games evaluated use an intangible reward system (58,3%) to reward individual actions, such as extra points, unblocking levels or virtual coins by answering a quiz question correctly, making sustainable decisions under time pressure or doing well in the skill games, whether it is by turning the street lights off quickly or by matching the cause/consequence images of climate change. It is also worth mentioning that most of the games´ length is less than one hour and that game instructions are available, which makes it easier to be implemented by docents in class.

Didactics

Games evaluated are characterized by having different learning curves and difficulties, facilitating the development of the majority of competences assigned by
(2015) such as knowledge and interaction with the physic world (100%), social and citizen competence (75,0%), autonomy and personal initiative (50,0%), digital competence (45,8%), and mathematical competence (41,7%). Following Bloom Taxonomy, the abilities that are promoted the most are applying, evaluating and creating. As positive aspects we highlight the interdisciplinarity of games, allowing their use for different courses, and the possibility of group work by sharing computers when playing; and as a negative aspect, the fact that the majority of games do not

include didactic guidelines to help teachers implementing the game at class. In addition, just two cases are available for students with functional disability.

4.5.4. Conclusions

The games evaluated seem to have incorporated the recommendations given by scholars like Sheppard (2012) on how to communicate climate change: (1) make it local, (2) make it visual, and (3) make it connected. The majority of the games provides a local discourse and shows a general preference towards portraying an ordinary citizen and local scenarios, in which players make decisions at home or within their communities to reduce carbon emissions. Through the present-future connection, accompanied by contextual information with references to climate change causes and consequences, games allow players to make decisions in the present and then travel into the future, where they can see the consequences of their choices in a visual manner, an advantage corroborated by similar studies (Schroth et al., 2014). In addition, most of the games present a positive discourse, not only through the pro-action and direct tone of the messages, but also through the game design with the feedback and reward system. Focusing on solutions, as well as positive and localized stories, has been suggested as a strategy for raising awareness and enhancing engagement (Maibach et al. 2010, Sheppard, 2012).

On the other hand, there is still room for improvement in various areas. Regarding the messengers, we miss more participation from research and scientific institutions, as well as organizations and game developers from Latin America. Looking at the contents, there is a lack of a climate change adaptation perspective: just three games explicitly focus on these issues, and a good example of that is *Alto a los desastres!* A greater degree of critical perspectives on the issue, by for instance framing messages in terms of justice, solidarity, mobilization or sustainable life-styles, is also highly encouraged. Good examples include *Actúa con tu consumo* or *3rd World Farmer*. In addition to this, we believe that games that address climate change should avoid addressing other environmental concepts such as depletion zone or acid rain in order to avoid misconceptions and relations; incorporating a team of scientists will help to achieve this purpose and ensure scientific accuracy. In regards to gameplay, it seems there is a trend in using simulations for energy-related games and puzzles or ability games for waste management-related games. Some of the games evaluated tend to use very simplistic game structures, which can reduce players´ intrinsic motivation and provide limited learning experience. Challenge should be more encouraged. A greater integration of comradeship dynamics and cooperation mechanisms in their structure and design would also be highly recommended to call for collective action and efficacy. In this sense, the field of online climate change games could have a closer look at massively multiplayer online games, which enable players not only to compete but also to cooperate with each other in meaningful ways. Lastly, the inclusion of didactic guidelines and accessibility are also advisable.

Future research should focus on the impact and effectiveness of these games on players learning and engagement. We also encourage researchers, educators and game designers to make use of proposed checklist. The dimensions and evaluation criteria can be transferable to other types of online games in general, but especially those ones centred in scientific and environmental areas.

4.5.5. References

Aguaded-Gómez, I. (2011). Niños y adolescentes: nuevas generaciones interactivas. *Comunicar 36*(XVIII), 7-8.

Aparici, R. & Silva, M. (2012). Pedagogía de la Interactividad. *Comunicar, 38*(XIX), 51-58.

Bloom, B. S. (1956). *Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain*. New York: David McKay Co Inc.

Bofferding, L. & Kloser, M. (2015). Middle and high school students' conceptions of climate change mitigation and adaptation strategies. *Environmental Education Research 21*(2), 275–294.

Díaz-Nosty, B. (2013). Aproximación a la construcción interdisciplinar y de un Nuevo paradigma. Comunicación, cambio climático y crisis sistemática. *Razón y Palabra*, *84,* 99-119.

Frasca, G. (2007). *Play the Message: Play, Game and Videogame Rhetoric* (Unpublished doctoral dissertation). IT University of Copenhagen

Katsaliaki, K., & Mustafee, N. (2014). Edutainment for Sustainable Development: A survey of Games in the Field. *Simulation & Gaming, 1*(26), 1-26.

León, B. *et al. (2013). El periodismo ante el cambio climático. Nuevas perspectivas y retos. Barcelona:* UOC.

LOMCE - *Ley Orgánica para la Mejora de la Calidad Educativa* de 2015. Orden ECD/65/2015, de 21 de enero

Maibach, E., Nisbet, M., Baldwin, P., Akerlof, K., & Diao, G. (2010). Reframing Climate Change as a Public Health Issue: An Exploratory Study of Public Reactions. *BMC Public Health 10*: 299–309.

Meira et al., 2013.*La respuesta de la sociedad española ante el cambio climático 2013.* Madrid: Instituto de Prevención Salud y Medioambiente.

Moser, S.C. (2010). Communicating Climate Change: History, Challenges, Process and Future Directions. *WIREs Climate Change, 1*, 31-53.

Pérez-Latorre, O. (2010). *Análisis de la significación del videojuego. Fundamentos teóricos del juego, el mundo narrativo y la enunciación interactiva como perspectivas de estudio del discurso* (Unpublished doctoral dissertation). Universitat Pompeu Fabra, Departament de Comunicació, Barcelona.

Prensky, M. (2001). Digital natives, digital immigrants. *On The Horizon*, *9*(5), 1-6.

Reckien, D., & Eisenack K. (2013). Climate Change Gaming on Board and Screen: A review. *Simulation and Gaming, 44*(2-3), 253-271.

Reig, R. (2010). Condicionantes estructurales del trabajo del periodista: las causas de una sociedad desinformada. *Global Media Journal, 7*(14), 39-59.

Scapolo, F. & Miles, I. (2006). Eliciting expert´s knowledge: A comparison of two methods. *Technological Forecasting and Social Change, 73*, 670-704.

Schroth, O., Angel, J., Sheppard, S. & Dulic, A. (2014). Visual Climate Change Communication: From Iconography to Locally Framed 3D Visualization. *Environmental Communication, 8,* 413–432.

Sheppard, S.R.J. (2012). *Visualizing climate change: A guide to visual communication of climate change and developing local solutions*. Abingdon, Oxon: Routledge

Wu, J. & Lee, J. (2015). Climate change games as tools for educational and engagement. *Nature Climate Change, 5*, 413-418.

CHAPTER 5: ANALYSIS OF THE EFFECTS OF GAMES

Once we know what online climate change games look like "in theory", it would be logical to advance our knowledge and better understand the impacts of these types of games in changing young people´s awareness, knowledge and attitudes to fully assess the potential of these educommunicative tools. Article 6 aims to examine the effectiveness of the game *2020 Energy* in changing climate change and energy-related awareness, knowledge and attitudes among teenagers from two different nationalities: Spain and the United States of America (USA).

The game was preselected by the researcher and finally selected by the middle-school docents for fitting their curriculum and for its feasibility to be used in class. The game, supported by the European Comission, follows a quiz format and is focused on energy issues in the content of climate change and sustainable development. In fact, mitigating climate change requires a change in energy attitudes and behaviors. Every time we burn fossil fuels to produce energy, we release carbon dioxide into the atmosphere, which is one of the main sources of the greenhouse gases responsible for global warming and climate change. Teenagers are an important target. One the one hand, they are high energy consumers of electrical energy (Bell et al. 2016): research shows that households with an adolescent use 20% more electricity than households with the same number of adults due to their "technology-dependency" (Gram-Hanssen 2005; Oblingeer & Oblinger, 2005). On the other hand, they are also the next generation of adult consumers.

Contents promoted are addressed through: a) the responsibility and impact of our actions on the society, b) the temporal dimension of our actions and their consequences in the long run; and c) the links between the individual, local and global scale of the issues. The following table summarizes the missions and the main messages:

Mission	Key messages
Holiday	• Always remember to consider the different means of transportation at your disposal • For short trips, choose transportation that make you workout. They produce no pollution or greenhouse gases and are good for your health
Traffic congestion	• The way cities are built has an impact on the use of transport and thus on the energy spent • For small distances use a bike, skateboard, or even better your own feet • Public transportation consumes energy, but on the scale of an individual traveler, it consumes muss less than a car with a single passenger
Feed the world	• Transportation and distribution of consumer goods like food require energy • By consuming seasonal local food you limit the energy consumption needed for production and storage • The consumption of imported goods require 10 to 20 times more energy than local and seasonal food
Dress code	• Even inanimate objects consume energy • Do not throw away • Buy locally produced goods whenever possible. It reduces the energy used for transport and also boots the local economy
Ghost town	• By improving insulation of houses and buildings, we decrease energy consumption • There is an energy label for houses and buildings which gives an indication of the potential energy consumption • There are passive houses. Their energy consumption is very low and sometimes even approaches zero

More efficiency	• Guidelines will be implemented in 2020 by each country in their own way to produce 20% more renewable energy, improve energy efficiency by 20% and emit 20% less CO2 • There is no label for sustainable products. However, there is already an energy label that lets you know about the product energy efficiency
Community center	• You can power your home with renewable energy • Do not hesitate to take the lead
The island	• Renewable energies are inexhaustible resources such as the wind, the sun, etc. • There are numerous types of sustainable energies: wind, solar, geothermal, tidal power… There is a type of sustainable energy for every situation
Back to the future	• Research and innovation are important factors for the development of renewable energy • There is no unique good solution • If we want to mitigate climate change, governments all across the world have to reduce energy consumption and increase the use of renewable energies

Table 2. Summary of missions and messages in *2020 Energy*

According to web analytics, here are other important game statistics:

- Nº of sessions: 6.269
- Nº of users: 4.936
- Nº of page visits: 10.292
- Nº of active users per day: 70
- Main countries of origins: France, United States, Sweden, Colombia, Spain, Italy, Canada, Greece, Tunisia and Mexico

Article 6 provides more details on the game, on how it was implemented in class and the methodology used in this empirical study, in which 108 students (58 from Spain and 50 from USA) were divided into two conditions, the experimental condition (playing) and the control condition (not playing), and filled in a pretest two weeks before the intervention and a posttest just after playing / not playing.

Even though we cannot formulate a universal generalization further than the data of our own sample, global results indicate that statistically significant differences do not exist in the three categories we measure in our study (awareness, knowledge and attitudes) in relation to the intervention applied to the experimental sample; that means that the game itself does not cause an improvement in awareness ($p=0,519$, $\alpha=0,05$), knowledge ($p=0,825$, $\alpha=0,05$) and attitudes ($p=0,881$, $\alpha=0,05$) on climate change and energy-related issues. However, when looking closer at each of the items, the findings reveal that a) there are some slight positive changes in the experimental groups, mostly in awareness (risk perception, self-awareness) and knowledge (understanding on sustainable development), and lastly attitudes (self-efficacy), and that b) the game has had a bigger impact on Spanish students than American. These results are complemented with observations and group discussions with students, which revealed that they would have liked better graphics, more challenge and other type of interactive mechanics in the game.

The article presented in this chapter interpretates further these findings and offers recommendations for game designers and docents.

5.1. The impact of online games on awareness, knowledge and attitudes: the case of 2020 Energy

Article 6: Ouariachi, T., Gutiérrez-Pérez, J., & Olvera-Lobo, M.D. (2017). "The impact of online games on awareness, knowledge and attitudes: the case of 2020 Energy", in *Innovación Universitaria: digitalización 2.0 y Excelencia en contenidos*, Editorial McGraw Hill. ISBN- 978-84-48612-71-9 (in press).

In a pretest-posttest design an empirical study tested whether change in attitude was different for people playing the persuasive game *Energy 2020* compared to a control condition where participants read a document with highly similar information. No significant differences in increase of attitude or knowledge between participants that played the game and participants in the informative control condition were found. Based on the results of the literature review and the empirical study presented, it hence cannot be concluded that playing a game leads to a greater change in attitude or knowledge acquisition than experiencing conventional media would.

5.1.1. Introduction

Every time we burn fossil fuels to produce energy, we release carbon dioxide into the atmosphere, which is one of the main sources of the greenhouse gases responsible for global warming and climate change. Therefore, encouraging sustainable energy use by individuals has become one of the main challenges of our time. In search of innovative approaches targeting young people, online games are growing as strategic communication and education tools. Videogames in general, and online games in particular, can offer experiential learning, transforming passive consumers of information into active players who absorb new information more readily; simulate unfamiliar circumstances that aren't possible in real life, linking decisions to consequences; and inspire out-of-the-box and critical thinking.

In response to the limitations of the traditional educational model, this experiential learning though online games is been transferred to formal education under the paradigms of educommunication- teaching about and with communication media in the school curriculum (Aparici, 2010)- and digital game-based learning (DGBL)- an instructional method that incorporates learning principles into videogames (Gee, 2003; Prensky, 2001). In Primary education, games have become a basic element of school activities, but in Secondary education this approach has not been adopted so often yet. However, nowadays there is an increasingly growing interest by teachers due to the fact that students at this stage dedicate many hours to playing videogames and surfing the web (Ruiz-Dávila et al, 2008).

Online games on sustainability, energy conservation and climate change targeting youth, considered serious games because they intend to fulfill a purpose, have experienced most of their progress in the last 10 years (Reckien & Eisenack, 2013) with examples like *EnerCities* (2011), *ElectroCity* (2007), *Efficient City* (2001), *EnergyVille* (2011), *Clim'Way* (2010), *BBC Climate Challenge* (2010) and *CityOne* (2011). Since little empirical research on the impacts of these types of games is available to date, the main objective of this chapter is to conduct an empirical study that examines the impact of the serious game *2020 Energy* in changing students´ climate change and energy-related awareness, knowledge and attitudes. Based on the literature review, we

hypothesize that awareness and knowledge of participants playing the game increase more than that of participants in the control condition, while attitudes remain the same. The research employs a pretest-posttest design with a control condition in which students do not play the game. Next, we provide a literature review and a theoretical approach to this topic, we describe the game and methodology, we present the results, and we end up with a discussion, conclusions and recommendations.

5.1.2. The persuasion of serious games

Serious games can be understood as games intended to fulfill a purpose, to convey ideas and values and sometimes at persuading the players (Frasca, 2007). Scholars argue that serious games can be an effective tool to increase awareness and knowledge, but also to change people's attitudes. The mechanism through which this process occurs is that "playing a game can lead to a state of flow or immersion where players are extremely concentrated and time passes unnoticed", which can lead to a higher awareness and understanding of relevant factors involved in the game (e.g. energy saving), and in effect, to a positive change in attitude which can subsequently trigger a change in behavior itself (Soekarjo & van Oostendorp, 2015). Scientists have argued that "experientially derived knowledge" through vivid and concrete information is often more compelling to influence attitudes than "abstract knowledge" is, and that "when people change their attitudes, they are more likely to change their behavior" (Aronson et al, 2013).

Other authors argue that even though knowledge has been shown to shape cognitive and affective perception of climate change and to be relevant for public support of government initiatives, knowledge does not necessarily translate into individual voluntary action (Seebauer, 2013). The dominant theoretical models maintain that behavior is governed by the interplay of different psychological key determinants such as knowledge, attitude, beliefs, subjective norms, self-efficacy and intentions (Glanz et al., 2002). One of those dominant theoretical models, the Theory of Planned Behavior (Ajzen, 1985), postulates that behavioral intentions are guided by the degree to which this particular behavior is valued positively or negatively; the degree to which people think their social environment likes or wants them to demonstrate certain behavior; and finally, the degree to which people believe they are able to demonstrate the focal behavior.

Research on the impact and effectiveness of serious games is an emerging field of study. On the one hand, some scholars emphasize the potential of serious games. Ruiz-Dávila et al. (2008) makes use of the game *BBC Climate Challenge* with 60 teenagers in high school and show in a qualitative study how they learnt which activities helped to reduce CO2 emissions and the difficulty of governing and balancing decisions between correct and popular. Dib & Adamo-Villani (2014) describe the development and initial evaluation of the serious game *Sustainability Challenge*. Results of a summative study with 42 undergraduate students shows that, compared to traditional learning methods, playing the game led to significantly higher procedural knowledge gains, and less significantly higher in declarative knowledge. Pettenger et al. (2013) assess the impact of role play simulations related to climate change negotiations on learning in Canadian and US classrooms by identifying the learning outcomes and aligning them with four knowledge domains (factual, conceptual, procedural, and metacognitive). The data in

this analysis demonstrate that role play simulations are an educationally effective means of conveying factual, conceptual, procedural, and metacognitive knowledge.

On the other hand, scholars like Soekarjo & van Oostendorp (2015) maintain that the impact of serious games is very limited. In their research, they first conducted a literature review of studies that empirically evaluates the effectiveness of persuasive games. They found out that limited empirical evidence is currently available to prove their effectiveness in attitude change. In addition, in a pretest-posttest design an empirical study tested whether change in attitude was different for people playing *EnerCities* compared to a control condition where participants read a document with highly similar information. The researchers did not find significant differences in increase of attitude or knowledge between participants that played the game and participants in the informative control condition. Rebolledo-Mendez et al (2015) presents an evaluation of the societal impact of the simulation-based serious game *FloodSim.* By making use of semi-structured interviews and data left on the site, they found out that the game increased awareness but only at a basic level.

Since little empirical research on the impacts of these types of games is available to date, we aim to contribute to this emerging field using the serious game *2020 Energy* as a case study.

5.1.3. The game

For more than a century people have been using and depleting energy resources carefree, as if they were endless. In 2020 the world could find itself in a deadlock. The player has the power to go back in time and to rewrite history… This is the scenario in which players immerse when playing *2020 Energy*, a serious and educative online game on energy conservation in relation to climate change and sustainable development.

The game, produced by an enterprise specialized in digital education and innovation (TRALALERE) and supported by Intelligent Energy Europe (European Commission) in the framework of the multimedia project Energy-Bits targeting youth, offers 9 missions in which players have to take decisions by responding to questions with the aim to reduce the consumption of energy, increase energy efficiency and choose the best renewable energies. Players can count on the help of three advisors (economical, environmental, social) and a glossary of terms. The missions cover different issues addressed through: a) the responsibility and impact of our actions on the society, b) the temporal dimension of our actions and their consequences in the long run; and c) the links between the individual, local and global scale of the issues, as it can be observed in the following table:

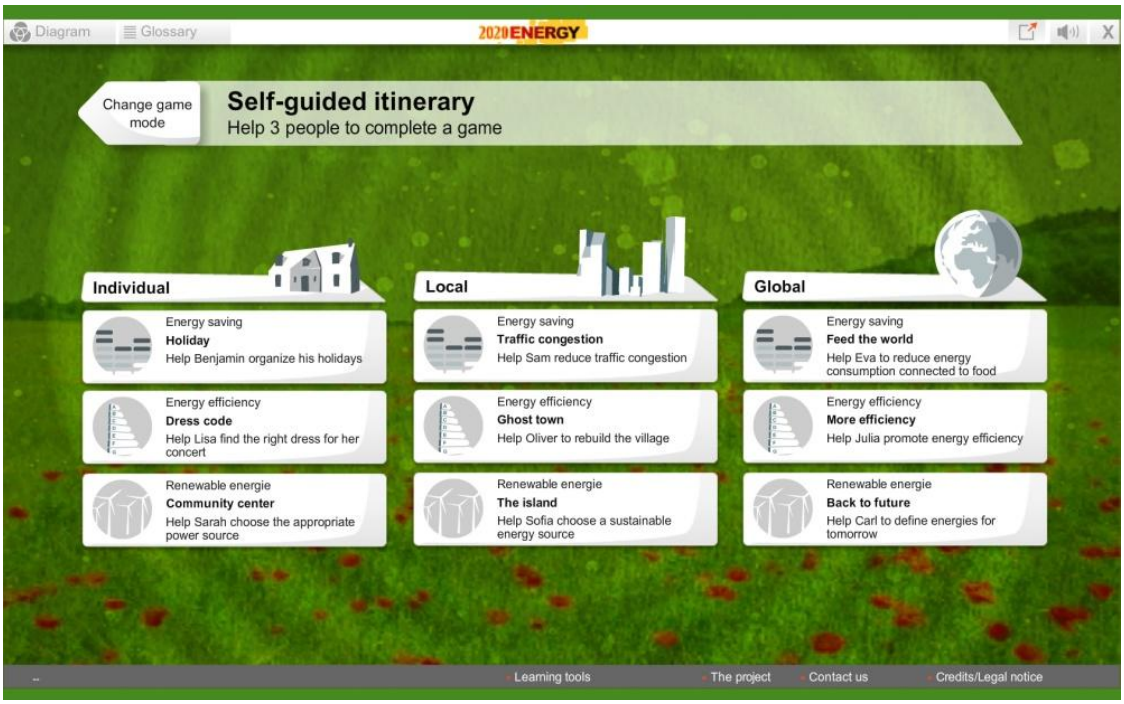


Figure 1. Missions proposed in the game. Source: ©TRALALERE; *2020 Energy* Serious Game

"Inspired by active learning, the serious game proposes an immersive learning mode to develop critical thinking and motivation", as stated on the website. All the questions posed in the missions apply a multiple choice format.

Figure 2. Example of question and answers posed in a mission. Source: ©TRALALERE; *2020 Energy* Serious Game

After a decision is taken, a graphic appears to inform the player if the decision has been equitable, livable, bearable or sustainable:

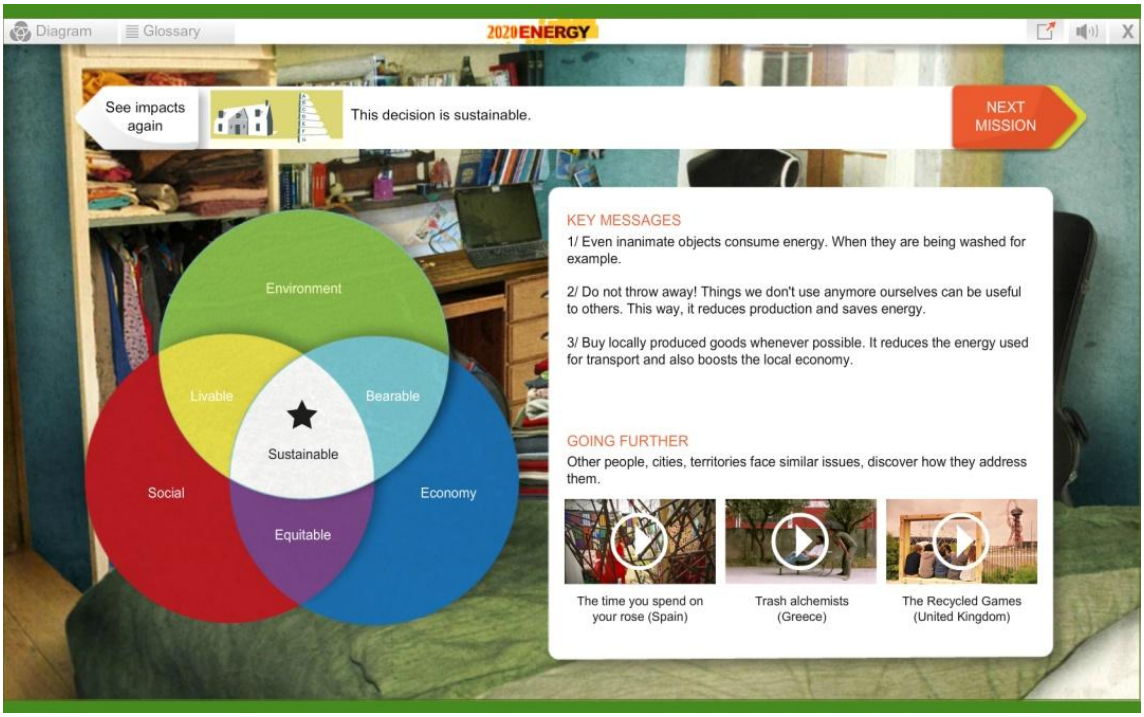


Figure 3. Feedback after decision-making. Source: ©TRALALERE; *2020 Energy* Serious Game

This game was chosen for the study for its feasibility to be used in class: short duration, easy use through quiz questions, possibility of evaluation, possibility of playing in couples in case of shortage of computers, and possibility of a guided itinerary for teachers, who can choose the missions that better fit the curriculum.

5.1.4. Methodology

This study uses a pretest-posttest design research. Participants' awareness, knowledge and attitudes regarding climate change and energy-related topics are assessed. Participants are divided into two conditions: the experimental condition (playing) and the control condition (not playing). We complement these results with observations and group discussions to get more qualitative data about their interaction with the game.

Sample, instrument and validation

In this study, a total of 108 students participated in this study: 58 students from Spain (24 males and 34 females) and 50 students from the USA (21 males, 28 females and 1 unknown gender) American students between the ages of twelve and fourteen. Both samples correspond to four different core groups in middle schools; therefore, one core group serves as experimental group and the other as a control group in Spain (experimental group: 30 students; control group: 28 students) and the USA (experimental group: 27 students; control group: 23 students). All students belong to middle-high classes and urban areas, and their teachers have previously addressed climate change very superficially in their science class. The game session and the questionnaires were planned as activities during class hours by their correspondent teachers.

Participants completed an online pretest as well as an online posttest questionnaire, both of which included 17 questions: open questions, multiple choice questions and rating scales. The pretest questionnaire served as baseline measurement in order to later calculate the changes of each participant. Both pretest and posttest practically contain the same questions and statements to assess the categories of awareness, knowledge and attitudes:

* Awareness was investigated based on three factors (concern about climate change, risk perception and linkages, and self-awareness). In the first factor, students were asked to rate the statement "are you worried about climate change" on a four-point Likert scale ranging from respectively 'not at all' to 'a lot'*;* in the second factor, students were asked to respond with Yes/No/I do not know to three statements ("climate change is happening now"; "there is connection between production and use of energy and increasing emission of greenhouse gasses to the atmosphere", and "there is connection between the increasing emission of greenhouse gasses to the atmosphere and climate change"); and in the third factor, students were posed with a dichotomous question (Yes/No) to respond to another three statements ("I am aware of the impact of m actions and lifestyle on the environment"; "I know the right behavior to conserve energy or do not use energy at all"; and "I know measures and products to use energy in a more efficient way, allowing us to not waste energy"). Two open questions were added to test their self-awareness.

* Knowledge was researched based on five factors (attribution of responsibility, understanding on technological progress, understanding on sustainable development, understanding on energy sources, and attention to the game glossary of terms). In the first factor, students were asked about the causes of climate change with a three-point scale including human causes, natural causes or a combination, and responded to the multiple-choice question "which of the following activities produce greenhouse gasses"; in the second factor, they were asked to rate the statement "do you think natural resources will be always available thanks to technological progress?" on a four-point Likert scale ranging from respectively 'not at all' to 'a lot'; in the third factor and fourth factors, they responded to the multiple-choice questions "in which areas do sustainable development requires adopting measures?" and "which of these energy sources are considered clean?"; and in the fifth factor, they were posed with a contingency question to test if they paid attention to the glossary of terms.

*Attitudes were researched on two factors (self-efficacy and behavioral intentions). In the first factor, students were asked to rate the statement "it is very difficult for me to act to reduce the effects of climate change" on a four-point Likert scale ranging from respectively 'not at all' to 'a lot'; and in the second factor, they responded to the multiple-choice question "which of the following activities are you planning to do to reduce energy consumption?".

The questionnaires also include demographic questions (age, gender and country), a rating scale question on the frequency of videogame playing (only pre-test), an open-ended question together with a four-point Likert scale question ranging from totally disagree to totally agree in order to evaluate their interaction with the game (only in post-test for the experimental groups): how interesting they found the game, how much fun they had, how much they preferred the game compared to a normal class, how interested in learning more about the topic they were and if they would recommend the game to friends.

The coefficient of reliability of the scales calculated from Cronbach's alpha ranges from 0,628 to 0,842, acceptable values on scales of this nature. Content validity of the instrument used is determined by a selection of dimensions explored by other authors on aspects of awareness, knowledge and attitudes, filtered by a choice of three independent evaluators.

Questions and statements were compiled from similar previous studies (Cao & McGill, 2013; Dib & Adamo-Villani, 2014; Knock & De Vries, 2011; López-Becerra, 2012; Rebolledo-Mendez et al, 2009; Pettenger et al., 2013; Seebauer, 2013; Soekarjo & van Oostendorp, 2015) and were based on topics present in the game. Item wordings and response scales resemble these studies.

In addition, the questionnaires were pretested in Spain and in the USA for simple language and rephrased if necessary. A total of 30 students of the same age range than the sample of our study were asked to complete the questionnaires and to respond if they understood the questions; if the questions were too long; if the order of the questions made sense; if they understood response options; if they thought students might refuse to answer any questions; if they had a tendency to choose the "middle" response; and if they thought students might respond to the questions according to what it is considered "socially accepted by others" instead of giving their honest opinion.

Pretesting revealed that we had to eliminate "middle" responses (e.g. we converted scales from 1 to 5 towards 1 to 4); ensure in the introduction of the questionnaires that their responses would be anonymous; introduce a reliability question to test that their previous responses were true; and accompany some of the questions and statements with simple and clear examples in order to be understood properly by students. In the case of American students, we also incorporated the category "other" for gender to be consistent with the teachings and philosophy of the school. In addition to students´ feedback, we shared the questionnaires with their teachers to adapt them properly to teenagers' language.

Procedure and analysis

First of all, for the middle school classes in Spain and in the USA, permission for the intervention to the Board of Directors was applied for and accepted. In each school, one teacher worked hand-in-hand with the researchers from the beginning until the end of the intervention. The teacher was responsible for choosing two different groups for the intervention: one group played the game, while the other group did not play the game (control condition), following this planning:

GROUP 1: (2 weeks in advance) pre-test → GAMEPLAY → post-test
GROUP 2: (2 weeks in advance) pre-test → NO GAMEPLAY → post-test

All students completed the online pretest (5 min.) around two weeks before playing (experimental group) / not playing the game (control group) in order to reduce the chance of "sensitization", in which results at a subsequent measurement are potentially amplified due to repeated measurement (Shettleworth, 2010 cited Seebauer, 2013: 44). The Spanish teacher used the educative platform Edmodo and the American teacher their internal blackboard to communicate with their students and post the online questionnaires. In the case of the experimental group, students were not informed about

the game they were supposed to play two weeks later. The game session took place during a single class period in which the researchers introduced the game to students with a PowerPoint presentation (5 min.), and then let the students play the nine missions of the game (35 min.) in pairs due to a shortage of computers for all students- Spanish students played the game in Spanish and American students in English. Researchers also believe that playing in pairs would contribute to promote the discussion and the decision-making during the game, as well as create a more reflective and critical attitude by the players. They all were asked to choose the "guided itinerary" at the beginning of the game, so they could play the missions in the order they preferred. During the game play, the researchers observed and took notes of a) their face expressions; c) the chatting with their partner; and c) the questions and doubts they raised.

After finalizing the game, they completed the online posttest individually (5 min.) and participated in a group discussion (10 min.) guided by the researchers with the support of their teachers. The discussion was aimed to be a collective exchange of ideas to share their opinions about the game (e.g. interesting, fun, boring, etc.), the missions they enjoyed the most, their main take-away, and their predisposition to adjust their life-styles. The group discussion also helped researchers to gather more qualitative data on their interaction with the game. The control group just proceeded with their usual daily recess, instead of playing the game, and when they came back to class they also filled in the online posttest.

The researchers used Google Forms to compose and send the surveys online. The data was later transferred to the software SPSS Statistics in order to conduct statistical analysis. We translated the students´ names into numbers to guarantee their anonymity.

5.1.5. Findings

In order to examine whether there have been statistically significant differences after the intervention between the experimental and the control group, we conducted a Chi-squared test for each of the categories. Taking into account the sample limitations of the selected groups and its low representativeness, we cannot formulate a universal generalization further than the data of our own sample, where global results are in the direction of accepting the null hypothesis: statistically significant differences do not exist in the three categories of our study in relation to the intervention applied to the experimental sample (Table 1); that means that the game does not cause by itself an improvement in awareness (p=0,519, α=0,05), knowledge (p=0,825, α=0,05) and attitudes (p=0,881, α=0,05) on climate change and energy-related issues.

Hypothesis contrast: Impact of the game per country	Total N	Exp. Group	Contr. Group	Chi-squared test								
				Awareness			Knowledge			Attitudes		
				χ^2	gl	P	χ^2	gl	p	χ^2	gl	P
Spain: Contrast EG-CG	58	30	28	9,348	7	,229	16,633	17	,217	2,798	8	,946
USA: Contrast EG-CG	50	27	23	3,435	7	,633	10,591	17	,718	3,934	8	,863
Global: Contrast EG-CG	108	57	51	6,183	7	,519	11,581	17	,825	3,731	8	,881

Table 1. Chi-squared test for each of the categories in posttest (α=0,05)

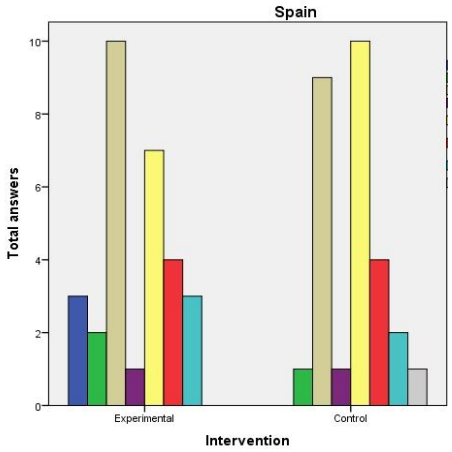
However, a more detailed analysis of the different items allow us to find differences in certain aspects:

*Risk perception: among Spanish teenagers, after playing there are more students (+20%) who believe climate change is happening compared to the control group (-18%). The game also reduced confusion and skepticism. To the question if climate change is happening now, 17% less students in the experimental group reported "I do not know" in the posttest compared to the pretest, compared to the 11% in the control group.

*Self-awareness: among Spanish teenagers, after playing there are 10% more students that claim to be aware of the impact of their actions and 17% more who are aware of measures and products to use energy in a more efficient way, compared to the control group that experienced a decrease. Among American students, 37% more students are more aware of energy efficiency measures after playing, while in the control group there is just an increase of 8% in the posttest. As examples for energy conservation behaviors, most students mention turning off lights and other electronically devices and water saving, and for energy efficiency, using solar panels and wind mills.

*Attribution of responsibility: when asked which activities produce greenhouse gasses, transportation, heating at home and deforestation are the most mentioned. The only activity that experience statistically significant difference in the posttest is product distribution and among American students (USA $p=0,019$, $\alpha=0,05$). Missions such as *Feed the world* informs that "production, transportation and distribution of consumer goods like food require energy" and promotes "supporting local producers and alternative ways to distribute their products". However, the percentage is higher in the control group than in the experimental group (USA experimental: 63%, control: 91,3%).

*Understanding on sustainable development: after playing the game half of the Spanish students understand that sustainable development is associated with environmental, societal and economical factors, around 37% more than in the pretest, while just 17% of students in the control group understand this concept in the posttest. As can be observed in Figure 4, American Students in both groups seem to already have a pretty close understanding of this concept, but in any case, in the posttest of the experimental group there is a bigger percentage of students who choose "environmental, societal and economic" as the main answer.



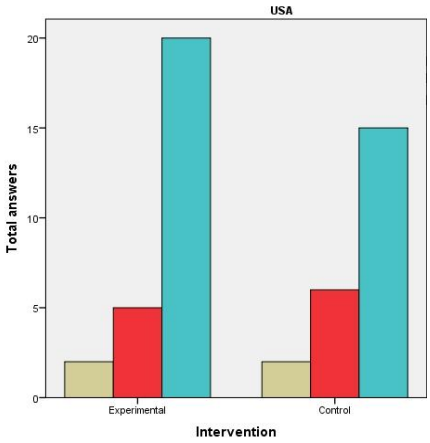
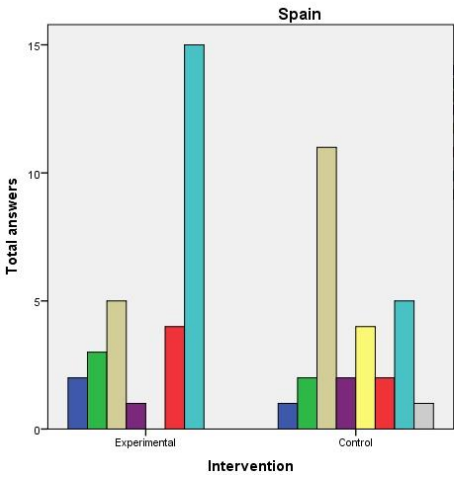


Figure 4 and 5. Bar diagramas of answers to question 13 in pretest



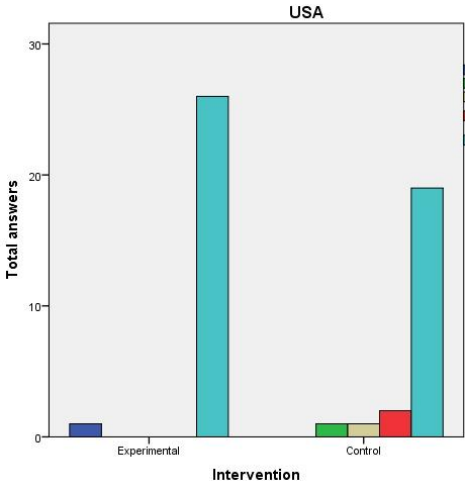


Figure 6 and 7. Bar diagramas of answers to question 13 in posttest

*Understanding on energy sources: when asked which energy sources are considered clean and environmental friendly, solar, wind, hydraulic and geothermal are chosen the most: in the case of Spain, after the intervention, wind energy increases +13,3% in the experimental and decreases -7,2% in the control; hydraulic energy increases +6,6% in the experimental group and decreases -14,2%; and geothermal increases +6,7% in experimental group, and just +3,5% in the control group. In fact, the mission *The island* includes as a key message that "there are numerous types of sustainable energies such as solar, wind, and geothermal". However, the scores in these items are still higher in the

control group during the posttest. Among American students, there are not significant changes.

*Self-efficacy: to the question if it is very difficult for them to reduce the effects of climate change, the majority believes it is not difficult and that they can act to address this issue. There is almost statistically significant difference between the experimental and control group in the posttest (Spain and USA, p=0,057, α=0,05). In the posttest, 20% more Spanish students believe they can act, compared to the 3,5% increase in the control group. Among the activities that are taken into consideration the most are electricity (turning off lights and computers) and sustainable transport (travelling by bus or bike).

Interaction with the game: findings from group discussion and observations

During the group discussions, American and Spanish students confirmed that they find the game interesting, fun and recommendable to friends. The majority of the students prefer playing the game compared to more traditional teaching methods. They enjoyed playing the game in pairs; they appreciated the advices provided by consultants in the game to guide their decisions; they acknowledged that they have learned more about this topic; and that they like feeling responsible and doing good in the game. Here are some of their comments:

> "I felt like an ecologist. I feel like reducing water consumption now and convincing my parents to use solar panels" (Spanish student).
> "I like the experience because I can take decisions by myself" (Spanish student).
> "The game made me feel good about making the right decisions. I felt like I was very responsible and in charge of my future" (American student).

Regarding the gameplay experience, we have observed how all students were mostly engaged with and motivated by the game, although American students seemed to be more silent and focused than the Spanish. American students also wanted to repeat missions until they would get the best answer, revealing the competitive spirit of teenagers. In fact, they did not like it when they got negative results, especially because they did not get an immediate feedback on what the most correct choice was. This might be a limitation of the game.

Figure 8. American students during the gameplay session at class

Criticism about the game by students mostly dealt with the game's design. Some students would have liked better graphics, more challenge (e.g. by including more levels and response options), and other types of interactive mechanics (e.g. by including also mini-games). That would have helped to make the game more engaging. One American student commented:

> "I would make the game a little more interactive. Rather than asking people to just click on an answer, let the player be able to physically place the solar panels on the house, etc."

The same criticism is presented by game scholars, who believe that educational games usually have difficulties achieving the high levels of engagement associated with commercial games. In fact, students from both nationalities have well understood the concept of "sustainable development" because it has been integrated in the gameplay in an interactive way (Figure 3). However, concepts like "passive house" that just appear in a glossary of terms outside of the gameplay have not been acquired.

Another interesting aspect is that when asked which missions they remember the most during the group discussion, students mentioned the missions that were closer to their daily lives or that they have experienced before, for instance, a mission where they have to help Lisa choose the most adequate clothes to go to a concert.

Finally, we observed how the game promoted reflection and critical thinking among students. In fact, one of the American students raised the question on how to feed the world population if we focus efforts on growing foods in gardens and supporting local products.

5.1.6. Discussion and conclusions

The results of this study show that there have not been statistically significant differences in awareness, knowledge and attitudes as a whole category. In the literature review, other studies can be found that use a similar research design with control condition and did not find a significant difference between these two conditions (Lavender, 2008; Soekarjo & van Oostendorp, 2015). However, when looking closer at each of the items, there are some slight changes, mostly in awareness and knowledge, and lastly attitudes.

A possible explanation for this lack of significant differences might be, first of all, that there was little room for improvement in the first place due to a quite environmentally friendly sample, especially the American one. On average, participants already had relatively favourable climate change and energy-related attitudes before playing the game. Perhaps their awareness and knowledge were also high a priori because their teacher superficially addressed the issue in class in the past. Secondly, there is a risk that answers were subject to a "social desirability bias", which means that respondents' answers might be influenced by what they believe is the socially acceptable answer (Fisher, 1993 cited Soekarjo & van Oostendorp, 2015: 48). Thirdly, as revealed by the questionnaires and the group discussions in relation to their interaction with the game, the design can also contribute to the results. According to Mitgush & Alvarado (2012), not only the players' mindset and the contextual framing of the play situation influences the impact of serious games, but also the way the purpose of games is channeled

through their conceptual design. Criticism has been posed by game scholars, who believe that educational games do not achieve the high levels of engagement associated with commercial games. In fact, students would have liked better graphics, more challenge and other type of interactive mechanics, and clear example of this is that students understood well the concept of "sustainable development" integrated in the gameplay but not the concept of "passive house" that only appeared in a glossary of terms outside of the gameplay.

Regarding the game session experience, the length of the game was perfect for a class. In around 50 minutes, there was time for debriefing, playing, filling tests and discussion. Teachers were interested and curious about the experience, positively surprised to see students so focused. As some scholars suggest, there is definitely a need for debriefing before playing the game and discussions after playing the game. For instance, during the discussion one student was wondering why growing food in gardens is a good solution if we have to feed a big population. This is a sign that games can, if not create in depth learning, at least open space for critical thinking and debate.

Based on the results, observations and discussions, we provide some recommendations for designing these types of games and implementing them in class as educommunicative resources:

1. Provide immediate feedback. Choosing the wrong answer and not getting the best score could be seen as frustrating for some students, so there is a need for immediate feedback of what is considered the best action in each mission.
2. Avoid static games. The game follows a strict format, and does not evolve in terms of complexity as the player continues playing. Players could be given the choice to select their maximum level of complexity, aiming at getting higher rewards in higher levels. In addition, it is suggested to integrate the concepts to be learned into the game mechanics, avoid glossary of terms and long texts.
3. Aim at meaningful engagement. Well designed online games can overcome the pressing challenge for communicators and educators on how to engage youth in climate change, encouraging them to think, feel and adopt measures to address environmental problems through the game. Therefore, the game could aim to achieve meaningful engagement through three categories: cognitive (understanding/knowledge), affective (emotion/interest and concern), and behavioral (action). This implies that "it is not enough for people to know about climate change in order to be engaged; they also need to care about it, be motivated and able to take action" (Lorenzoni et al., 2007: 446).
4. Despite the length of the game being very suitable for use in class… to what extent can a game be engaging during such a short time? How can they immerse students? Perhaps a way to solve this issue could be to include innovative teaching methods such as "flipped classrooms", where students work at home (in this case play the game) and use the time in class for discussions.

Finally, conclusions should be treated with caution. Here are some of the limitations and implications for future research: the sample size can be considered a limitation. To build stronger evidence of the impacts of the game on awareness, knowledge and attitudes, another research could research larger pools of players. The sample of students is also quite homogeneous (young, well-educated and from urban areas), so a future study could be a replication with a different sample, such as a rural group of students or a group of older participants. Finally, the game was played only once. Perhaps increased exposure to the content can increase the knowledge acquisition process because it leads to "redundant essential processing" (Soekarjo & van Oostendorp, 2015). Our research does not focus on changes of behavior in the short or long term. It is suggested to investigate possible effects just after playing or months later.

5.1.7. References

Ajzen I. From intentions to actions: A theory of planned behavior. In Kuhl & Beckman (Eds). *Action-control: From cognition to behavior*. Heidelberg, Springer, 1985;11-39.

Aparici R . *Educomunicación: más allá del 2.0.* Bogota, Gedisa, 2010.

Aronson E, Wilson TD, Akert RM. *Social Psychology*. Upper Saddle River, Pearson Education, 2013.

Cao Y, McGill W. LinkIT: A Ludic Elicitation Game for Eliciting Risk Perceptions. *Risk Analysis* 2013; 33(6).

Dib H, Adamo-Villani N. Serious Sustainability Challenge Game to Promote Teaching and Learning of Building Sustainability. *Journal of Computing in Civil Engineering* 2014; 28.

Frasca G. *Play the Message: Play, Game and Videogame Rhetoric* (Unpublished doctoral dissertation). Copenhagen, IT University of Copenhagen, 2007.

Glanz K, Rimer BK, Lewis F. *Health Behavior and Health Education*, 3rd ed. San Fransisco, John Wiley & Sons, 2002.

Gee JP. *What Video Games Have to Teach Us About Learning and Literacy*. New York, Palgrave Macmillan, 2003.

Knock E, De Vries PW. EnerCities, a Serious Game to Stimulate Sustainability and Energy Conservation: Preliminary Results. *eLearning Papers* 2011; 25.

Lavender TJ. *Homeless: It's No Game - Measuring the Effectiveness of a Persuasive Videogame* (Unpublished master thesis), Simon Fraser University, 2008.

López-Becerra F. Construcción y validación de un cuestionario sobre los hábitos de consumo de videojuegos en preadolescentes. *Revista Electrónica de Tecnología Educativa* 2012; 40.

Lorenzoni I, Nicholson-Colen S, Whitmarsh L. Barriers perceived to engaging with climate change among the UK public and their policy implications. *Global Environmental Change*, 2007; 17(3-4):445-459.

Mitgutsch K, Alvarado N. Purposeful by Design? A serious game design assessment framework. *Proceedings of the International Conference on the Foundations of Digital Games*, New York, ACM, 2012.

Ockwell D, Whitmarsh L, O'Neill S. Reorienting climate change communication for effective mitigation: Forcing People to be Green or Fostering Grass-Roots *Science Communication,* 2009; 30.

Pettenger M, Douglas W, Young N. Assessing the Impact of Role Play Simulations on Learning in Canadian and US Classrooms. *International Studies Perspectives*, 2013; 15:491–508.

Prensky M. Digital natives, digital immigrants. *On The Horizon*, 2001; 9(5):1-6.

Rebolledo-Mendez G, Avramides K, de Freitas S, Memarzia K. Societal impact of a serious game on raising public awareness: the case of FloodSim. In Spencer (Ed). Proceedings of the ACM SIGGRAPH Symposium on Videogames, New York, ACM, 2009; 15-22.

Reckien D, Eisenack K. Climate Change Gaming on Board and Screen: A review. *Simulation and Gaming*, 2013; 44(2-3):253-271.

Ruiz-Dávila M, Montero-Pascual ME, Díaz-Tejero B, López-Fernández de Córdoba CM. Videojuegos para tender puentes. Diálogo y aprendizaje puestos en juego. *Comunicación y Pedagogía*, 2008; 225.

Seebauer S. Measuring climate change knowledge in a social media game with a purpose. *IEEE*- 5th International Conference on Games and Virtual Worlds for Serious Applications (VS-GAMES), 2013.

Soekarjo M, van Oostendorp H. Measuring Effectiveness of Persuasive Games Using an Informative Control Condition. *International Journal of Serious Games*, 2015; 2(2).

PART III

CONCLUSIONS / CONCLUSIONES

CHAPTER 6: DISCUSSION AND CONCLUDING REMARKS

Climate change is currently considered one of the world´s biggest challenges, and scientific reports tell us that the worst is still to arrive. Recent studies suggest that the lack of engagement with the issue, especially among young people, is not due to a lack of information to make decisions, but due to the way and tools through which information is delivered. Taking into account the large amount of time that young people spend playing online games, the question is what the potential of these innovative educommunicative tools to engage the "interactive" or "digital" generation in the fight against climate change is. In order to respond to this question, we have defined potential as: 1) the ability to communicate climate change, facing the challenges posed by traditional media, and the ability of using this tool in formal education contexts, considered as key places where young people consume information, facing the challenges posed by a traditional pedagogical model; and 2) the ability to have an impact on young people´s awareness, knowledge and attitudes.

In this thesis we have tackled the first approach by analyzing the educommunicative nature of online climate change games. As with television or cinema, video games also generate stories told through a screen, with the peculiarity of being an interactive media. In *Homo Ludens*, Huizinga already wrote in 1938 that every game means something. Gombrich (2004) expresses it like this: "there is no such thing as an innocent game". Since previous analysis instruments mostly focuses on general characteristics without considering both educative and communicative aspects -integrating a narratological (understands the game as a medium to generate stories and transmit contents) and a ludological view (pays attention to the meanings hidden behind the design)-, and without considering the peculiarities of climate change as the main topic, we developed a set of analysis criteria (**objective 1**). The use of the Delphi method allowed us to validate a total of 51 criteria divided into five different dimensions: identification, narrative, contents, gameplay and didactics.

These criteria were applied then in the analysis of two different samples of online climate change games targeting youth: games produced in Spain and games produced in Spanish language (**objective 2**). The findings from these analyses reveal positive trends on how to communicate climate change, as recommended by scholars like Sheppard (2012): a) make it local –to avoid psychological distance-, b) make it visual –to make climate change more real and memorable-, and c) make it connected –to provide a sense of agency-.

Most of the games we have analyzed provide a local discourse, portraying ordinary citizens and focusing on local scenarios, in which players must make decisions at home, within their communities or on territories they have to manage to reduce greenhouse gasses to the atmosphere. Players are able to see through visual representations the causes and consequences of climate change, and simulate unfamiliar circumstances. Many games present a positive and empowering discourse, not only through stories and messages that focus on possible and realistic actions, but also through the gameplay by for instance providing feedback, praise and rewards when the right decisions have been made. Focusing on visible solutions, as well as localized stories and positivism, while being realistic about the magnitude of the problem, has been considered by climate change communication scholars as a strategy for cognitive, emotional and behavioural

engagement (Maibach et al. 2010; Moser & Dilling, 2011; Sheppard, 2012; Schroth et al., 2014). And this is a different approach than the one traditionally taken by mass media in communicating climate change (González-Gaudiano & Meira-Cartea, 2009; Díaz-Nosty, 2013; León, 2014, Meira-Cartea, 2008).

While many games follow a "pragmatic optimist discourse" appealing to "small actions" in our daily lifes to contrarest climate change (González-Gaudiano, 2012), such as turning off lights or using more public transportation, there are also good examples of games that combine global, national and local dimensions, showing the complexity of climate change, and call for collective action by for instance participating in movilizations or putting pressure on politicians.

However, some aspects have also been identified that could still be improved. One of these aspects is the integration of more climate change adaptation contents, which is important for countries like Spain, where there is a risk of desertification due to increasing temperatures and a reduction in precipitation (Martínez-Valderrama et al., 2016). Trying to convey several environmental issues and concepts in one game such as depletion zone or acid rain can also be risky because this can lead to misconceptions and confusion (Meira-Cartea, 2015). In relation to contents, a more critical approach to the climate change topic is missing, by for instance, appealing not only to efficiency but also to solidarity and cooperation among people and among countries in international climate negotiations (which correlates with the lack of cooperation mechanics in the gameplay). There is also lot of attention paid to CO2 and less to methane gas, which in order to be reduced requires eating less meat, among other measures.

Another approach that could be addressed in games is related with building and supporting an alternative economic model that goes beyond "green" economy, technological progress and consumerism. Naomi Klein (2015) in her book "*This changes everything: capitalism vs. the climate"* suggests that the liberal ideology triumph has "systematically sabotaged the actions needed to respond to this crisis": the rise of free trade, austerity policies, or the privatization of the energy sector. Some games of our sample promote this liberal ideology through contents or game design, by for instance using virtual currency for transactions and rewarding investing in energy stocks. Interestingly enough, some games of our sample have been produced by electrical companies with a bad reputation when it comes to greenhouse gasses emissions, which raises concerns on the real purpose of the game and the risk of covering an *advergame* as an educational game. Authors like Chaparro-Escudero (2013) or Latouche (2004) believe that concepts like sustainable development, which is actually promoted in many games, continue favoring a "suicidal" economic model and suggest adopting a degrowth model, organized to provide the necessary. Latouche (2004) summarizes it in seven principles: reevaluate, reconceptualize, restructure, redistribute, relocalize, reduce and reuse.

Finally, we also consider that taking more advantage of their online format to converge with social networks like Facebook could be another strategy to move forward, since the use of social media can increase the likelihood to return to the website or post their gaming scores and compare themselves to others, increasing social pressure (CRED, 2014).

In terms of educative features, our sample of games facilitates the development of the majority of competences assigned by LOMCE (2015), offer possibilities to be used for different courses and disciplines, for group work by and for evaluation by docents. We have also spotted good examples in which critical thinking is encouraged, opening spaces for debate and reflection about our lifestyles and consumption, as well as taking actions in the real world (e.g., doing surveys, organzing community campaigns, making alist of local products, etc.). However, the majority does not include didactic guidelines to help teachers implementing the game at class and few are available for students with functional disability.

Saying this, taking an active role and being more than mere information consumers are nowadays key factors to engage the younger generation; the ability to intervene in the content and receive feedback, as well as the capacity of immersion are intrinsic characteristics of online games that can overcome the challenges posed by the unidirectional communicative paradigm of mass media and pedagogical models. But is this enough? According to our empirical study in which we tested the impact of a game on Spanish and American students´ awareness, knowledge and attitudes using an experimental (playing the game) and a control condition (not playing the game), the answer is that it is not enough (**objective 3**). The findings reveal that there have not been statistically significant differences. In the literature review, other studies can be found that use a similar research design with control condition and did not find a significant difference between these two conditions (Soekarjo & van Oostendorp, 2015). Possible explanations for this are that there was little room for improvement in the first place due to a quite environmentally friendly sample -especially the American one-, the "social desirability bias" when responding the questionnaires, and the interaction of players with the game as revealed by the group discussions with students.

Students suggested that they would have liked better graphics, more challenge and other type of interactive mechanics, and clear example of this is that students understood well the concept of "sustainable development" promoted by the game, which was integrated in the gameplay, but not the concept of "passive house" that only appeared in a glossary of terms outside of the gameplay. In fact, criticism has been posed by game scholars, who believe that serious games do not achieve the high levels of engagement associated with commercial games, appealing to the difficulties in integrating educational and social issues into gameplay terms, and in conciliating the playful with the serious (Rodríguez-Hoyos & João Gomes, 2013; Mitgutsch & Alvarado, 2012).

Therefore, we can conclude that the potential of online climate change games depends not only on the educommunicative nature of games, but also on players' mindset and the way the communicative and learning purposes are channeled through their conceptual design. The results of this thesis show that even though the game seem to be on the right track in terms of communicating climate change -by making the issue local, visual and connected-, in practice other important factors contribute to its effectiveness.

Conclusions should be treated with caution. On the one hand, our analysis of the educommunicative nature of online climate change games focusses on a specific sample of games produced in a specific country and a specific language. On the other hand, to analyze their impact, we use one game (*2020 Energy*) as a case study, and a small sample of students. But even though conclusions cannot be generalized, the findings do provide a first approach to an emerging field of study that deserves greater attention.

CHAPTER 7: RECOMMENDATIONS AND FURTHER RESEARCH

Based on the results from our study, here we provide a summary and 10 recommendations for designing and using online climate change games:

1. Aim at meaningful engagement through three categories: cognitive (understanding/knowledge), affective (emotion/interest and concern), and behavioral (action): "it is not enough for people to know about climate change in order to be engaged; they also need to care about it, be motivated and able to take action" (Lorenzoni et al., 2007).
2. Integrate climate change adaptation contents and criticial approaches to the current economic model and consumerist society, making use of meaningful narratives.
3. Games should appeal to players´ identities. Creating inspiring characters that the players care about or giving players choices for customization could result in increased personal connection. Pay attention to cultural aspects of the target group (clothes, dialects, music, colors, etc.) in order to adapt the messages and aesthetics of the game, and therefore, tailor it to their personal experiences.
4. Provide immediate feedback after decisions are taken in the game. Choosing the wrong answer and not getting the best score could be seen as frustrating for some players, so there is a need to inform on what is considered the best action.
5. Avoid static games that follow a strict format and do not evolve in terms of complexity and challenge as the player continues playing. The game should have the appropriate level of difficulty for the player to be pushed to the limit of his/her capacity.
6. Integrate the concepts to be learned into the game mechanics avoiding glossary of terms and long texts. Experiential learning and fun are important components.
7. Integrate cooperation mechanisms in the structure and design of games to encourage collective action and enhance efficacy. Online climate change games could have a closer look at massively multiplayer online games (MMOGs), which enable players not only to compete but also to cooperate with each other, and sometimes to interact meaningfully with other players around the world (Wagner, 2008).
8. Make the game available through a mobile app. With over three billion smartphone users worldwide, the power of mobile is big. Mobile gaming opens possibilities for new formats such as location-based games or augmented reality games. This way, we bridge digital and physical, extending the gaming experience into the real world and increasing the chance of behavioral engagement.
9. Include didactic guidelines on the website to help teachers implementing the game at class and make games available for students with functional disability.
10. Despite the length of the game being very suitable for use in class, there is a risk that the game is not immersive enough. A way to solve this issue could be to include innovative teaching methods such as "flipped classrooms", where students work at home (in this case play the game) and use the time in class for discussions and debates, opening spaces for critical thinking.

This thesis opens up lines for future research and exposes areas that need further analysis:

1. The proposed analysis instrument with criteria vetted through the Delphi method can be useful for researchers, game designers, communicators and educators. Even though they were conceptualised to analyse online climate change games, the instrument could be tested with other types of games and other topics.
2. An analysis of online climate change games in other countries and other languages could be useful to make comparisons and to draw conclusions at a global level.
3. There is a need to study the narratives that generate the most interest among young people in depth, as well as to examine in more detail the scientific rigour and quality of the climate change contents in online games. In relation to that, it would be interesting to find out how and who is behind "translating" the science that backs up the game; explaining a complex issue such as climate change in simple terms is a task that deserves attention.
4. More research is needed to identify which variables are relevant to effective learning with serious games. Some authors predict that both learner variables (such as gender, prior knowledge, and age) and game context variables (such as the content, feedback and interactivity) may moderate the effectiveness of games.
5. To build stronger evidence of the impacts of the game on awareness, knowledge and attitudes, another research could use larger and more heterogenous pools of players. Other questions emerging from this study are related to the impacts of these games on behavior change in the short and long-term.

REFERENCES

Center for Research on Environmental Decisions & ecoAmerica. (2014). *Connecting on climate: A guide to effective climate change communication*. New York, NY: Author.

Chaparro-Escudero, M. (2013). Construcción de un imaginario perverso. La comunicación del desarrollo. *Telos, 94*, 31-42.

Díaz-Nosty, B. (2013). Aproximación a la construcción interdisciplinar y de un nuevo paradigm: Comunicación, cambio climático y crisis sistemática. *Razón y Palabra*, *84*, 99-119. doi:10.4185/RLCS-64-2009-808-99-119

Gombrich, E. H. (2004). *El sentido del orden*. *Estudio de la psicología de las artes decorativas* (The sense of order. A study of the psichology of the decorative art). Madrid: Debate.

González-Gaudiano, E. & Meira-Cartea, P.A. (2009). Educación, comunicación y cambio climático. *Trayectorias, 11*(29), 6-38.

González-Gaudiano, E. (2012). Educación y cambio climático: aportes de las representaciones sociales. *Revista Contemporânea de Educação*, 7(14), 369-397.

Huizinga, J. (1938). *Homo ludens: El elemento lúdico de la cultura*. Madrid, Spain: Alianza.

Klein, N. (2015).This changes everything: capitalism vs. the climate. New York: Simon & Schuster Paperbacks.

Latouche, S. (2004). *Come sopravivere allo sviluppo*. Torino: Bollati Boringhieri.

León, B. (Coord.). (2014). *El periodismo ante el cambio climático: Nuevas perspectivas y retos*. Barcelona, Spain: Editorial UOC.

LOMCE - *Ley Orgánica para la Mejora de la Calidad Educativa* de 2015. Orden ECD/65/2015, de 21 de enero

Lorenzoni I., Nicholson-Cole S., & Whitmarsh L. (2007). Barriers perceived to engaging with climate change among the UK public and their policy implications. *Global Environmental Change 17*(3–4), 445 459. doi:10.1016/j.gloenvcha.2007.01.004

Maibach, E., Nisbet, M., Baldwin, P., Akerlof, K., & Diao, G. (2010). Reframing climate change as a public health issue: An exploratory study of public reactions. *BMC Public Health*, *10*, 299-309. doi:10.1186/1471-2458-10-299

Martínez-Valderrama, J., Ibáñez, J., Del Barrio, G., Sanjuán, M. E., Alcalá, F. J., Martínez-Vicente, S., & Puidgefábregas, J. (2016). Present and future of desertification in Spain: Implementation of a surveillance system to prevent land degradation. *Science of the Total Environment*, *563-564*, 169-178. doi:10.1016/j.scitotenv.2016.04.065

Meira-Cartea, P.A. (2008). *Comunicar el cambio climático. Escenario social y líneas de actuación.* Madrid: Ministerio de Medio Ambiente y Medio Rural y Marino-Organismo Autónomo de Parques Nacionales.

Meria-Cartea, P.A. (2015). ¿Hay un agujero en la capa de ozno de tu camio climático? De la cultura cientñifica a la cultura común. *Metode, 85*, 49-55

Mitgutsch, K., & Alvarado, N. (2012). Purposeful by design? A serious game design assessment framework. In *Proceedings of the International Conference on the Foundations of Digital Games* (pp. 121-128). New York, NY: ACM.

Moser, S. C., & Dilling, L. (2011). Communicating climate change: Closing the science-action gap. In J. S. Dryzek, R. B. Norgaard, & D. Schlosberg (Eds.), *Oxford Handbook of climate change and society* (pp. 161-174). Oxford, England: Oxford University Press.

Rodríguez-Hoyos, C., & João Gomes, M. (2013). Videojuegos y educación: una visión panorámica de las investigaciones desarrolladas a nivel internacional. *Revista Profesorado*, *17*, 480-494.

Schroth, O., Angel, J., Sheppard, S., & Dulic, A. (2014). Visual climate change communication: From iconography to locally framed 3D visualization. *Environmental Communication*, *8*, 413-432. doi:10.1080/17524032.2014.906478

Sheppard, S. R. J. (2012). *Visualizing climate change: A guide to visual communication of climate change and developing local solutions*. Abingdon, England: Routledge.

Soekarjo M., & van Oostendorp H. (2019). Measuring Effectiveness of Persuasive Games Using an Informative Control Condition. *International Journal of Serious Games*, 2(2), 6-20.

Wagner, M. D. (2008). *Massively multiplayer online role-playing games as constructivist learning environments* (Unpublished doctoral dissertation). Walden University, Minneapolis, MN.

CAPÍTULO 6: DISCUSIÓN Y CONCLUSIONES

El cambio climático es considerado el centro de muchos de los desafíos actuales a los que se enfrenta la Humanidad, y los informes científicos nos dicen que lo peor está aún por llegar. Estudios recientes sugieren que la falta de compromiso con el cambio climático, especialmente entre los jóvenes, no se daba tanto a una falta de información para tomar decisiones sino a la manera y los métodos que se han usado para transmitir esa información. Teniendo en cuenta la cantidad de horas que los jóvenes emplean detrás de sus ordenadores interactuando con juegos online, nos preguntamos ¿cuál sería el potencial de estas herramientas educomunicativas para comprometer a la generación "interactiva" o "digital" en la lucha contra el cambio climático? Para responder a esta pregunta, hemos definido potencial como: 1) la habilidad de comunicar el cambio climático y de usar esta herramienta en contextos educativos formales, lugares clave de consumo de información para los jóvenes, haciendo frente tanto a las debilidades de los medios de comunicación convencionales como a los modelos pedagógicos tradicionales; y 2) la habilidad de provocar un impacto sobre la concienciación, conocimientos y actitudes de los jóvenes.

En esta tesis hemos abordado la primera perspectiva analizando la naturaleza educomunicativa de los juegos online de cambio climático. Al igual que la televisión o el cine, los video juegos también generan historias contadas a través de una pantalla, con la peculiaridad de ser medios interactivos. Huizinga ya dijo en 1938 que todo juego significa algo. Y Gombrich (2004) lo expresaba así: "los juegos inocentes no existen". Instrumentos de análisis previos se han centrado en las características generales de los juegos sin considerar aspectos educativos y comunicativos –integrando la perspectiva narratológica (entiende el juego como un medio para generar historias y transmitir contenidos) y ludológica (atiende a los significados detrás del diseño del juego), y sin considerar las peculiaridades de la temática del cambio climático, por lo tanto, definimos unos criterios consensuados de análisis (**objetivo 1**). El uso del método Delphi nos permitió validar 51 criterios categorizados en cinco dimensiones distintas: identificación, narrativa, contenidos, jugabilidad y didáctica.

Estos criterios fueron aplicados al análisis de dos muestras de juegos distintas: juegos producidos en España y juegos disponibles en español (**objetivo 2**). Los resultados de estos análisis revelan tendencias positivas en la comunicación del cambio climático, tal y como recomiendan autores como Sheppard (2012): a) hazlo local –para evitar una distancia psicológica-, b) hazlo visual –para hacer del cambio climático algo real y memorable-, y c) hazlo relacional –para ofrecer un sentido de confianza en las capacidades individuales y colectivas para hacer frente al cambio climático-.

La mayoría de los juegos analizados mantienen un discurso local, mostrando ciudadanos corrientes en escenarios locales en los que el jugador toma decisiones en su casa, en su comunidad o en territorios a gestionar para reducir los gases de efecto invernadero. Los jugadores son capaces de ver a través de representaciones visuales las causas y consecuencias del cambio climático y simular situaciones que no son familiares. Muchos de los juegos presentan también un discurso positivo y de empoderamiento, no sólo a través de las historias y los mensajes centrados en acciones realistas y posibles, sino también a través de la jugabilidad, por ejemplo, a través de la retroalimentación constante, y los elogios y recompensas al tomar decisiones correctas.

Visibilizar las soluciones, usar historias locales y positivismo, a la vez que se muestra la magnitud del problema, se ha considerado una estrategia para comprometer cognitiva, emocional y conductualmente a las audiencias (Maibach et al. 2010; Moser y Dilling, 2011; Sheppard, 2012; Schroth et al., 2014); y esta estrategia es distinta a la que vienen empleando tradicionalmente los medios de comunicación (González-Gaudiano y Meira-Cartea, 2009; Díaz-Nosty, 2013; León, 2014, Meira-Cartea, 2008).

A pesar de que muchos juegos de nuestra muestra siguen un "discurso optimista pragmático" recurriendo a "pequeñas acciones" en nuestras vidas diarias para contrarrestar el cambio climático (González-Gaudiano, 2012), tales como apagar luces o usar transporte público, también hay buenos ejemplos de juegos que combinan las dimensiones globales, nacionales y locales, y llaman a la acción colectica, por ejemplo, participando en movilizaciones sociales o poniendo presión sobre los políticos.

Sin embargo, también se han identificado algunos aspectos que podrían mejorarse. Uno de ellos es la falta de contenidos sobre adaptación al cambio climático, un factor importante para países como España que sufren un riesgo de desertificación debido al aumento de temperaturas y reducción de precipitaciones y que puede tener consecuencias graves en sectores económicos importantes como la agricultura o el turismo, así como en la salud (Martínez-Valderrama et al., 2016). Otro aspecto es aunar distintas problemáticas y conceptos medioambientales en un mismo juego, como el agujero de la capa de ozono o la lluvia ácida, ya que existe el riesgo de crear más duda y confusión en torno a las causas y consecuencias del cambio climático (Meira-Cartea, 2015). En relación a los contenidos, se echa en falta una perspectiva más crítica, por ejemplo, recurriendo no sólo a la eficiencia sino a la solidaridad y cooperación entre personas y entre países en las negociones internacionales (se refleja en la falta de mecánicas de cooperación en el diseño de los juegos). También se presta demasiada atención al CO2 y menos al gas metano, que para reducirlo se requiere comer menos carne, entre otras acciones

Otra perspectiva que podrían abordar los juegos está relacionada con construir y apoyar modelos económicos alternativos que vayan más allá de la economía "verde", el progreso tecnológico y el consumismo. Naomi Klein (2015) en su libro "*This changes everything: capitalism vs. the climate"* sugiere que el triunfo de la ideología liberal "ha saboteado sistemáticamente las acciones necesarias para responder a esta crisis": el incremento del libre comercio, las políticas de austeridad, o la privatización del sector energético. Algunos juegos en nuestra muestra promueven esta ideología liberal a través de contenidos y su diseño, por ejemplo hacienda uso de monedas virtuales para las transacciones y premiando la compra-venta de energía en el mercado de valores. De hecho es interesante observar como algunos juegos de nuestra muestra han sido producidos por compañías eléctricas con un serio historial de emisión de gases invernadero a la atmósfera, lo que plantea dudas sobre los objetivos reales de estos juegos por el riesgo de enmascarar un *advergame* en un juego educativo. Autores como Chaparro-Escudero (2013) o Latouche (2004) sostienen que conceptos como "desarrollo sostenible", el cual se promueve en mucho d elos juegos, continúa favoreciendo un modelo "suicida" y sugieren adoptar un modelo de decrecimiento, organizado para proveer lo necesario. Latouche (2004) lo resume en siete principios: Reevaluar, reconceptualizar, reestructurar, redistribuir, relocalizar, reducir y reutilizar.

Finalmente, también consideramos que los juegos podrían tomar ventaja de su formato online para integrar redes sociales como Facebook, ya que tienen el potencial de incrementar la probabilidad de que los jugadores vuelvan a la web o de que escriban un post con sus resultados en el juego y lo comparen con otros, aumentando la presión social (CRED, 2014).

En cuanto a las características educativas, nuestra muestra de juegos facilita el desarrollo de la mayoría de las competencias asignadas por la LOMCE (2015), ofrece posibilidades para usarse en distintas materias y disciplinas, para trabajar en grupo y como instrumento de evaluación de los docentes. Existen buenos ejemplos en los que se promueve el pensamiento crítico, abriendo espacios de debate y reflexión a cerca de nuestros estilos de vida y pautas de consumo, además de promover acciones en el mundo real (ej: hacer encuesta en la comunidad, organizar campañas de sensibilización, hacer una lista de productos locales, etc.). Sin embargo, la mayoría de los juegos no ofrecen guías didácticas que ayuden a los docentes a implementar el juego en clase y pocos son los disponibles para estudiantes con discapacidad.

Dicho esto, tomar un rol activo y dejar de ser meros consumidores de información son factores clave hoy en día para comprometer a los jóvenes; la habilidad de intervenir sobre el contenido y recibir retroalimentación, así como la capacidad de inmersión se pueden considerar características intrínsecas de los juegos online que pueden encarar a los desafíos del paradigma comunicacional unidireccional que ha caracterizado a los medios de comunicación de masas y a los modelos pedagógicos. Pero ¿es esto suficiente? Según nuestro estudio empírico en el que examinamos el impacto de un juego en la concienciación, conocimiento y actitudes de estudiantes españoles y estadounidenses usando un grupo experimental (que juega) y un grupo control (que no juega), la respuesta es que no es suficiente (**objetivo 3**). Los resultados muestran que no hay diferencias estadísticamente significativas entre los dos grupos. En la revisión bibliográfica, aparecen otros estudios que usan un diseño similar con grupos de control y que tampoco encuentran diferencias significativas (Soekarjo y van Oostendorp, 2015). Posibles explicaciones que ayudan a interpretar estos resultados tienen que ver con que la muestra ya era bastante simpatizante con el medio ambiente y por lo tanto existía poco margen de mejora, especialmente entre los estadounidenses; el riesgo de "deseabilidad social" al responder las preguntas; o las críticas lanzadas por los estudiantes en torno al su interacción con el juego.

Tal y como revelaron los estudiantes durante los grupos de discusión, echaron en falta mejores gráficos, más desafíos y otro tipo de mecánicas de juego; un ejemplo claro de esta crítica es que los estudiantes captaron bien el concepto de "desarrollo sostenible" promovido por el juego al estar bien integrado en las mecánicas del juego, mientras que el concepto de "casa pasiva" no lo llegaron a asimilar por estar definido en un glosario de términos externo. De hecho, diversos autores comparten las críticas y afirman que los *serious games* no han alcanzado los altos niveles de diversión y "*flow*" asociados a los juegos comerciales, planteando las dificultades de integrar temas educativos y sociales a la jugabilidad, y conciliar lo divertido con lo serio (Rodríguez-Hoyos y João Gomes, 2013; Mitgutsch y Alvarado, 2012).

Por lo tanto, podemos concluir que el potencial de los juegos online sobre cambio climático depende no sólo de su naturaleza educomunicativa, sino también de la mentalidad de los jugadores y la manera en la que los objetivos comunicativos y de

aprendizaje se canalizan a través de su diseño conceptual. Los resultados de esta tesis muestran que a pesar de que los juegos muestren tendencias positivas en la comunicación del cambio climático –al hacer el tema local, visual y relacional-, en la práctica hay otros factores importantes que contribuyen a su efectividad.

Las conclusiones deberían tratarse con cautela. Por un lado, nuestro análisis de la naturaleza educomunicativa de los juegos online sobre cambio climático se centra en una muestra específica de juegos procedentes de un país y disponibles en un idioma. Por otro lado, para analizar su impacto hemos hecho uso de un solo juego (*2020 Energy*) como estudio de caso, y una muestra pequeña de estudiantes. Aunque las conclusiones no puedan generalizarse a toda la población de juegos de este tipo, si es cierto que los resultados ofrecen un primer acercamiento a un tema de estudio emergente que merece más atención.

CAPÍTULO 7: RECOMENDACIONES Y FUTURAS INVESTIGACIONES

Basados en los resultados de esta investigación, aquí ofrecemos un decálogo de recomendaciones para diseñar y usar juegos online de cambio climático como herramientas educomunicativas:

1. Aspirar a crear un compromiso con el cambio climático en los niveles cognitivos (entendimiento, conocimiento), afectivos (emociones, intereses), y conductuales (acciones): "no es suficiente saber a cerca del cambio climático para comprometerse en su lucha; también es necesario que a la gente le importe el tema, esté motivada y tome acciones" (Lorenzoni et al., 2007).
2. Integrar contenidos sobre adaptación al cambio climático y aspectos críticos al modelo económico actual y sociedad consumista, haciendo uso de narrativas significativas que conecten con los jugadores.
3. Los juegos deberían apelar a la identidad de los jugadores. Crear personajes inspiradores o dar posibilidades de personalización en el juego podrían incrementar la conexión personal con el tema. Es necesario en este sentido prestar más atención a los aspectos culturales del grupo target (música, colores, ropa, etc.) para adaptar los mensajes y la estética del juego a sus experiencias.
4. Ofrecer retroalimentación inmediata tras tomar una decisión el juego. Escoger la respuesta incorrecta y no obtener el mejor resultado sin saber por qué puede ser frustrante para el jugador, por lo que se recomienda informar sobre aquellas acciones que se consideran adecuadas.
5. Evitar juegos estáticos que siguen un formato estricto y no evolucionan en términos de complejidad y desafíos. Los juegos deberían tener el nivel apropiado de dificultad para que los jugadores lleguen al límite de sus capacidades.
6. Integrar los conceptos a aprender dentro de las mecánicas del juego, evitando glosarios de términos y textos largos. El aprendizaje experiencial y la diversion son componentes clave.
7. Integrar mecánicas de cooperación dentro del diseño del juego para promover la acción colectiva. Los juegos online sobre cambio climático podrían adaptar algunas de las mecánicas usadas en los video juegos multi-jugador *masivos en línea, que permiten a los jugadores no solo competir sino también colaborar, a veces interactuando de manera significativa con otros jugadores en otras partes del mundo* (Wagner, 2008).

8. Hacer disponible el juego para aplicaciones móviles. Con más de tres billones de usuarios con s*martphones* en el mundo, los móviles tienen un gran potencial. Los juegos para móviles abren posibilidades con nuevos formatos como los juegos de realidad aumentada o juegos basados en localización mediante GPS. De este modo se consigue enlazar espacios virtuales y físicos, extendiendo la experiencia del juego la mundo real e incrementando las posibilidades de cambios conductuales.
9. Incluir guías didácticas en las páginas web que ayuden a los docentes implementar el juego en clase, además de poner los juegos a disposición de estudiantes con discapacidad.
10. A pesar de que haya juegos que por su duración puedan ser más fáciles de usar en clase, existe el riesgo de que esos juegos no sean lo suficientemente inmersivos. Una manera de solventar este problema es usar modelos de enseñanza innovadores como las "clases invertidas" (*flipped classrooms*), en las que los estudiantes trabajan en casa (por ejemplo interactuando con el juego), y usan el tiempo en clase para discutir y debatir.

Esta tesis abre líneas de investigacion futuras y expone áreas que necesitan más análisis:

1. El instrumento de análisis propuesto con criterios aprobados a través del método Delphi puede ser útil para investigadores, diseñadores de juegos, comunicadores y educadores. Aunque fueron conceptualizados para analizar juegos en la temática del cambio climático, el instrumento se podría testar con otro tipo de juegos y otro tipo de temas.
2. Un análisis de juegos de cambio climático procedente de otros países y en otros idiomas podría ser útil para establecer comparaciones y lanzar conclusiones a nivel global.
3. Existe la necesidad de estudiar con más detalle las narrativas que más interés generan entre los jóvenes, así como examinar en más profundidad el rigor científico y calidad de los conceptos ofrecidos en los juegos. En este sentido, sería interesante conocer cómo y quién está detrás de la "interpretación" de la ciencia, traduciendo conceptos complejos en términos más comprensibles.
4. Son necesarios más estudios que identifiquen qué variables son las más relevantes para el aprendizaje efectivo a través de los *serious games*. Algunos autores consideran que las variables del jugador (género, conocimientos previos y edad), así como las variables en torno al juego (narrativas, contenidos, retroalimentación, interactividad) pueden moderar la eficacia de los juegos.
5. El estudio del impacto de los juegos en la concienciación, los conocimientos y las actitudes de los jugadores es otro campo abierto. Otras investigaciones podrían hacer uso de otros juegos o de muestras poblacionales más grandes y heterogéneas y compara resultados. Otras cuestiones que emergen están relacionados con el impacto de los juegos en el cambio de comportamientos a corto y largo plazo.

REFERENCIAS

Center for Research on Environmental Decisions y ecoAmerica. (2014). *Connecting on climate: A guide to effective climate change communication*. New York, NY: Author.

Chaparro-Escudero, M. (2013). Construcción de un imaginario perverso. La comunicación del desarrollo. *Telos, 94*, 31-42.

Díaz-Nosty, B. (2013). Aproximación a la construcción interdisciplinar y de un nuevo paradigm: Comunicación, cambio climático y crisis sistemática. *Razón y Palabra*, *84*, 99-119. doi:10.4185/RLCS-64-2009-808-99-119

Gombrich, E. H. (2004). *El sentido del orden*. *Estudio de la psicología de las artes decorativas* (The sense of order. A study of the psichology of the decorative art). Madrid: Debate.

González-Gaudiano, E. y Meira-Cartea, P.A. (2009). Educación, comunicación y cambio climático. *Trayectorias, 11*(29), 6-38.

González-Gaudiano, E. (2012). Educación y cambio climático: aportes de las representaciones sociales. *Revista Contemporânea de Educação*, 7(14), 369-397.

Huizinga, J. (1938). *Homo ludens: El elemento lúdico de la cultura*. Madrid, Spain: Alianza.

Klein, N. (2015).This changes everything: capitalism vs. the climate. New York: Simon & Schuster Paperbacks.

Latouche, S. (2004). *Come sopravivere allo sviluppo*. Torino: Bollati Boringhieri.

León, B. (Coord.). (2014). *El periodismo ante el cambio climático: Nuevas perspectivas y retos*. Barcelona, Spain: Editorial UOC.

LOMCE - *Ley Orgánica para la Mejora de la Calidad Educativa* de 2015. Orden ECD/65/2015, de 21 de enero

Lorenzoni I., Nicholson-Cole S., y Whitmarsh L. (2007). Barriers perceived to engaging with climate change among the UK public and their policy implications. *Global Environmental Change 17*(3–4), 445 459. doi:10.1016/j.gloenvcha.2007.01.004

Maibach, E., Nisbet, M., Baldwin, P., Akerlof, K., y Diao, G. (2010). Reframing climate change as a public health issue: An exploratory study of public reactions. *BMC Public Health*, *10*, 299-309. doi:10.1186/1471-2458-10-299

Martínez-Valderrama, J., Ibáñez, J., Del Barrio, G., Sanjuán, M. E., Alcalá, F. J., Martínez-Vicente, S., y Puidgefábregas, J. (2016). Present and future of desertification in Spain: Implementation of a surveillance system to prevent land degradation. *Science of the Total Environment*, *563-564*, 169-178. doi:10.1016/j.scitotenv.2016.04.065

Meira-Cartea, P.A. (2008). *Comunicar el cambio climático. Escenario social y líneas de actuación.* Madrid: Ministerio de Medio Ambiente y Medio Rural y Marino-Organismo Autónomo de Parques Nacionales.

Meria-Cartea, P.A. (2015). ¿Hay un agujero en la capa de ozno de tu camio climático? De la cultura cientñifica a la cultura común. *Metode, 85*, 49-55

Mitgutsch, K., y Alvarado, N. (2012). Purposeful by design? A serious game design assessment framework. In *Proceedings of the International Conference on the Foundations of Digital Games* (pp. 121-128). New York, NY: ACM.

Moser, S. C., y Dilling, L. (2011). Communicating climate change: Closing the science-action gap. In J. S. Dryzek, R. B. Norgaard, & D. Schlosberg (Eds.), *Oxford Handbook of climate change and society* (pp. 161-174). Oxford, England: Oxford University Press.

Rodríguez-Hoyos, C., y João Gomes, M. (2013). Videojuegos y educación: una visión panorámica de las investigaciones desarrolladas a nivel internacional. *Revista Profesorado*, *17*, 480-494.

Schroth, O., Angel, J., Sheppard, S., y Dulic, A. (2014). Visual climate change communication: From iconography to locally framed 3D visualization. *Environmental Communication*, *8*, 413-432. doi:10.1080/17524032.2014.906478

Sheppard, S. R. J. (2012). *Visualizing climate change: A guide to visual communication of climate change and developing local solutions*. Abingdon, England: Routledge.

Soekarjo M., y van Oostendorp H. (2019). Measuring Effectiveness of Persuasive Games Using an Informative Control Condition. *International Journal of Serious Games*, 2(2), 6-20.

Wagner, M. D. (2008). *Massively multiplayer online role-playing games as constructivist learning environments* (Unpublished doctoral dissertation). Walden University, Minneapolis, MN.

CHAPTER 8: CASE STUDIES

The international character of this thesis has led to two research stays in different universities: George Mason University- Center for Climate Change Communication in USA, and Radboud University- Institute of Behavioral Sciences in The Netherlands.

The first academic mobility took place from February to June 2016 and was funded with a Fulbright scholarship (Ruth Lee Kennedy) and a UGR- CEI BioTic Granada scholarship (2015/2016 call). The Center for Climate Change Communication (next to the one located at Yale University) is the only one specialized in this field and is supported by institutions like NASA; it is well known for research frameworks such as the "Global Warming´s Six Americas" which is used by climate educators and communicators to achieve public engagement by segmenting the audience in six different groups that respond to climate change in their own distinct way: the alarmed, the concerned, the cautious, the disengaged, the doubtful and the dismissive.

The second mobility took place from February to April 2017 and it was funded with a Fundación CEIMAR – Erasmus+ scholarship (2016/2017 call). The Behavioral Science Institute contains a prestigious research program in Science Communication financed by the Netherlands Organization for Scientific Research (NWO) and the European Research Council (ERC). It is interdisciplinary and one of the few specialised in positive communication research. Research lines of interest in relation to this thesis include video games for health and young consumers. Both institutions are well positioned in the Shanghai ranking.

Through these experiences, the researcher has gathered vast knowledge on the fields of climate change communication, and persuasive communication through videogames. She has made use of these stays to follow different courses (e.g. Climate change and sustainability communication campaigns; Scientific Integrity), participate in congresses as a presenter and session moderator (e.g. Association for Environmental Studies and Sciences Annual Conference, Washington DC, 8-11 June 2016; II National Energy Education Summit, Washington DC, 7 June 2016), be part of different initiatives, collect, analyze and interpret data. This has also allowed the researcher to initiate different studies that contribute to build upon some of the research lines open by this thesis, as exposed in the previous chapter. Here we summarize some of the experiences, initiated studies and preliminary results.

8.1. Educommunication through climate change game jams

In an effort to create games to help prevent climate change, game jams are emerging as a new educommunicative trend. These are gatherings that challenge students, educators, scientists, and game designers to rapidly develop games that help people learn about the impacts of and solutions to climate change in an engaging and fun way. In the United States, the origins of this initiative go back to 2014 when the Office of Science & Technology Policy (OSTP) launched a Climate Education and Literacy Initiative to help connect American students and citizens with the best-available, science-based information about climate change.

> *"I'm calling for investments in educational technology that will help create… educational software that's as compelling as the best video*

game. I want you guys to be stuck on a video game that's teaching you something other than just blowing something up" - President Obama

In response to the President's call to action to create engaging educational software, federal agencies formed the Federal Games Guild, an associated group of 200 people getting together and talking about games within US government agencies, including the Army, National Aeronautics and Space Agency (NASA), the Environmental protection Agency (EPA) or the National Oceanic and Atmospheric Administration (NOAA). On the other hand, governmental experts (federal and non federal), climate scientists, educators and game designers collaborated to harness the potential of games and launched the first-ever education game jam hosted by the White House. The event was celebrated on 6-7 September 2014 and it gathered 100 game developers in Washington D.C., including Disney, Rovio, Sony or Ubisoft, teachers and students, who for four hours demonstrated their game prototypes, shared experiences and recommended ideas on how teachers and students could design better games. Since then, a series of climate change game jams have been organized.

In 2016, the researcher had the opportunity to be an active observer of a climate game jam focused on developing games related to water with topics such a changing sea levels, sea ice and glacier melt, ocean acidification, or shifting ecosystems. Teams of students were categorized into junior high school, high school and university; they were given few days to work as game design teams, supported by their docents, to come up with game prototypes that span a range of platforms (online, pervasive, tabletop, or other formats), considering science facts and how a changing climate affects us all. No previous experience with game design was mandatory. Game ideas were submitted via a 2-minute video to be considered by a panel of game and climate experts using a scoring rubric to determine top selections by age categories. Some of the prizes for winners were being included at the Smithsonian's new Learning Lab to make the game available to educators across the nation; being showcased in an arcade on the grounds of the Smithsonian's National Museum of Natural History; or being provided with support from GlassLab Games for integration into their platform, distribution channel, and regular meetings to provide advice on seeking funding for further development.

These are some pictures taken at the Smithsonian's National Museum of Natural History showcase:

Figure 5. Peg Steffen, NOAA´s Education Coordinator giving a lecture

Figure 6 and 7. Winners from the 2016 Climate Change Game Jam

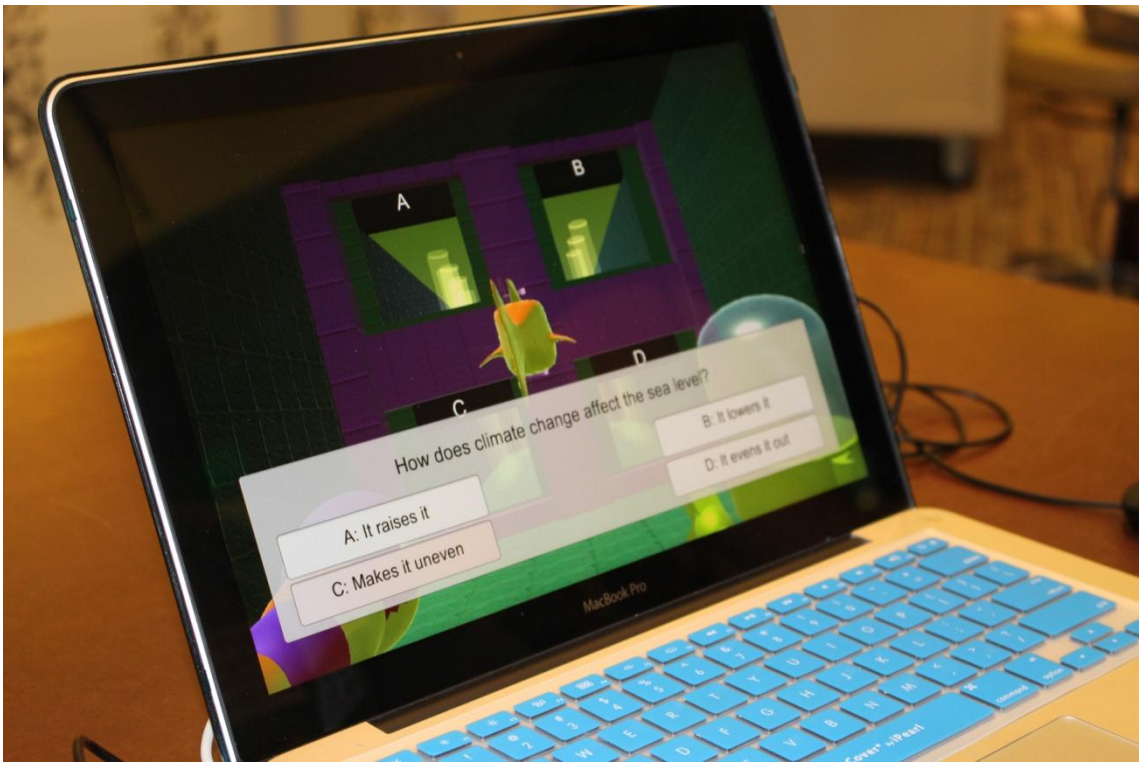


Figure 8. Example of game developed by students

Discussions were held with some of the winners, who acknowledged how much they have learned about climate change causes and consequences in the process of designing games. They had to find climate change facts by themselves and integrate them into their games, learning to differentiate trustable sources of information. They also had the support of experts from NOAA, who were on call for a whole week to attend students´ questions. This is therefore a good educommunicative practice. Media literacy is provided by letting students act as designers and think in terms of communication, considering principles, communicative goals and target audiences. Initiatives like this, which could also be implemented in Spain, show how climate change communication and education can be made into an engaging and fun experience. It also reveals the importance of institutional commitment and collaboration between different actors to empower young people in the fight against climate change.

8.2. A comparative analysis and quality assessment between Spanish and American online climate change games

What are the communicative and educational trends in other countries? Do these types of games share similar characteristics? As we stated in the chapter on future research lines, further analyses of online climate change games in other countries and other languages could be useful to make comparisons and to draw conclusions at a global level. To initially contribute to this research gap, we identified, selected and analyzed a sample of online climate change games produced in United States, following the same methodology to analyze the sample of games produced in Spain (see Article 4): we used the Delphi criteria and applied content analysis, which provides more quantitative information, as well as narratology and ludology, focusing on the relationships between game narrative and design.

A comparative analysis between serious games produced in two different countries can provide a rich overview. The United States has been at forefront of climate change games development. As explained earlier, the White House Office of Science & Technology Policy launched the Climate Education and Literacy Initiative, and since then, Federal and non-governmental experts have been collaborating to harness the promise of serious games, and supporting national initiatives like Climate Game Jams. In Europe, other countries like Spain are currently experiencing its video game development "golden age" -it ranks fourth in Europe and ninth in the world - (DEV, 2015), and have experienced an increase of these types of serious games.

In total, 30 games were analyzed and compared (15 Spanish and 15 Americans):
*Spanish games: Actúa con tu consumo / *Act on your consumption;* Alerta CO2 / *CO2 Alert;* Climántica; Controla / *Control;* De primero, reciclaje / *Recycling first;* El juego de la separación en casa / *The home sorting game;* Eneragen, el juego de la energía / *Eneragen, the energy game;* Fluvi y el ciclo del agua / *Fluvi and the water cycle;* Game sostenibilidad / *Sustainability Game;* Isla 100% / *Island 100%;* Misión posible, salvar el planeta / *Mission possible, save the planet;* My Green Energy Planet; Multijuegos forestales / *Forestry multigames;* Oca de la bioenergía / *Bioenergy goose game;* Todo un mundo de energía / *A whole world of energy.*
*American games: *Citizen Science; Disaster Hero; Dumptown; Energy City; Garbage dreams; Green Ninja- Carbon Command; Plant it Green; Plan it Now; Plan your future park; Raiders of the lost bark; Survive global warming 3- the aftermath; The riverbed: an eco-noir mystery; Tinysasters; Where the rivers meet the sea; Windfall.*

The preliminary results from this comparative analysis revealed that there are differences in terms of communicative and educative features between Spanish and American games, particularly in the following criteria: type of creator, communicative purpose, global storyline, character depiction and role, term used, explicit use of scientific concepts, message framework, game mission, game dynamics and mechanics, problem resolution conditions need for previous knowledge and learning curve. These differences might be related with the different socio-cultural contexts of each country. The following table (Table 3) summarizes those criteria that share similar and different characteristics among Spanish and American games:

Dimensions	Evaluation criteria (Similarities = ✓ Differences = X)		Summary of findings (Sp=Spain; USA=United States of America)
Identification	location on the web	✓	section from the producer´s web
	type of creator	X	Sp: NGO, enterprise; USA: private, public sector
	availability of app	✓	no availability of app
	free of charge	✓	free of charge
	language/s	✓	mostly their official language/s
	target audience	✓	+ 12 years-old
	communicative purpose	X	Sp: familiarity, attitude; USA: familiarity, causes
Narrative	relevance of narrative	✓	medium-high
	global storyline	X	diverse storylines
	character depiction and role	X	mostly ordinary citizens; USA more diversity
	representation of the environment	✓	representation of the environment
	dimension/space/scale	✓	fictitious places; local scales
	dimension/time	✓	present time; present-future
Contents	term used	X	Sp: climate change; USA: none
	existence of false concepts and misconceptions	✓	no existence of false concepts
	explicit use of scientific concepts	X	Sp: use of concepts; USA: no use of concepts
	explicit use of information sources	✓	no explicit use of information sources
	convergence with other media or social networks	✓	no convergence with other media or social
	message framework	X	Sp: mitigation, human causes; USA: mitigation and adaptation, no explicit causes, alarmist tones
Gameplay	number of players and type of use	✓	individual use
	player type	✓	explorer and competitor
	degree of interactivity	✓	medium-high
	length of playing	✓	less than 30 min.
	game mission	X	diverse game missions
	game dynamics and mechanics	X	Mostly challenge. Sp: ability; USA: fantasy
	feedback system	✓	neutral feedback: positive and negative
	reward system	✓	use of rewards: points, virtual coins
	availability of game instructions and possibility of saving the game	✓	game instructions availa—ble; no possibility of saving the game
Didactics	competences	✓	physic world, social and digital competences
	abilities	✓	apply, evaluate, create
	problem resolution conditions	X	Sp: memory; USA: memory and creativity
	need for previous knowledge	X	Sp: yes; USA: no
	learning curve	X	Sp: medium; USA: low
	possibility of group work	✓	group work is possible
	accessibility	✓	no accessibility
	interdisciplinary	✓	interdisciplinary
	availability of didactic guidelines	✓	didactic guidelines available
	possibility of evaluation by teachers	✓	evaluation by docent is possible

Table 3. Similar and different criteria

In order to assess the quality of the games, we selected those criteria that were considered the most relevant among experts during the Delphi process. For that purpose, we first created a ranking by assigning points to each of the criteria: considering that low importance is 1 point, medium 2 and high 3, and that 11 out of 13 experts participated in the second stage of the Delphi process, the maximum score that could be achieved was 33 points. Then, we calculated the divide line of the second third of the ranking, which was 29, and selected those criteria that scored higher. Finally, we provided a definition of quality and a scale of scores for each of the criteria (Table 4).

Dimensions	Criteria / Quality definition low quality=2 pt. / medium quality =4pts. / high quality =6pts.	Score
Identification	• **Availability of mobile app (max. 4PTS)** Low (towards medium): no app available Medium (towards high): app for one system • **Communication purpose (max. 6PTS)** Low: it develops familiarity with the topic Medium: it raise awareness on causes and consequences High: it raise awareness on causes and consequences, promotes attitude and behavior change, and stimulates critical thinking and solutions development	TOTAL: 10pts
Narrative	• **Representation of the environment (6PTS)** Low: it does not present any story Medium: it presents a story without any emotional impact or inspiring characters High: it presents a story with emotional impact and inspiring characters • **Dimension/space (6PTS)** Low: it detects one scale (global, national, regional or local) Medium: it detects two scales High: it detects two or more scales with emphasis on the local • **Dimension/time (6PTS)** Low: static view, without changes in time Medium: intermediate situation with jumps between past, present or future High: evolution in time with connections between past, present and future	TOTAL: 18pts
Contents	• **Explicit use of scientific concepts (6PTS)** Low: it does not introduce any concept Medium: it presents concepts only through a glossary of terms or external links High: it presents concepts integrated into the game mechanics • **Explicit use of information sources (6PTS)** Low: it does not present any information source Medium: it presents sources that are not clearly verifiable High: it presents sources that are verifiable • **Convergence with social networks (6PTS)** Low: it does not include links to social networks Medium: it includes links to social networks High: it includes links to social networks and allows other forms of participation outside of the game • **Message framework / main themes (6PTS)** Low: it centers only on one thematic area related to climate change mitigation or adaptation alone Medium: it centers on more than one thematic area related to climate change mitigation or adaptation High: it centers on one or more thematic areas related to both climate change mitigation and adaptation perspectives • **Context / causes (6PTS)** Low: it does not present causes Medium: it presents only natural causes High: it presents human causes • **Context/ promotion of actions (6PTS)** Low: it does not inform on actions to solve climate change Medium: it informs on actions to solve climate change at the individual level only High: it informs on actions to solve climate change at the individual and collective levels	TOTAL: 36pts
Gameplay	• **Player type (6PTS)** Low: it promotes only one player type (explorer, competitor, creator, collaborator) Medium: it promotes two player types High: it promotes two or more player types, including the collaborator • **Game dynamics/mechanics (6PTS)** Low: it employs only one dynamic/mechanic Medium: it employs two dynamics/mechanics High: it employs more than two dynamics/mechanics • **Feedback system (6PTS)** Low: the player does not receive any feedback at all after taking a decision in the game Medium: the player receives feedback only at the end of the mission or game High: the player receives feedback immediately after taking a decision in the game • **Availability of game instructions (4PTS)** Low (towards medium): it does not provide any instructions Medium (towards high): it provides instructions	TOTAL: 22pts
Didactics	• **Need for previous knowledge (6PTS)** Low: the difficulty level does not correspond with the cognitive level of the target group, so the game becomes too easy or too difficult Medium: the game does not demand enough effort from the player and it is limited to only one level of difficulty High: the game pushes the player to the limit of his/her capacities, having to pass different levels of difficulty	TOTAL: 14pts

• **Possibility of group work (4PTS)** Low (towards medium): it does not offer any group work possibility Medium (towards high): it offers group work possibilities
• **Availability of didactic guidelines and possibility of evaluation by teachers (4PTS)** Low (towards medium): it does not offer didactic guidelines or possibility of evaluation Medium (towards high): it offers didactic guidelines and possibility of evaluation
TOTAL SCORE: 100 pts.

Table 4. Criteria, quality definition and scores for assessing the quality of games

As in the analysis of games, in this case the two researchers did the evaluation marking the scores in a file that contained the selected Delphi criteria, agreed on those results that were different and reached a consensus to establish a final score. The following table (Table 5) shows the scores of each of the games.

Games in Spain	I	N	C	G	D	Total score		Games in USA	I	N	C	G	D	Total score
Game 1	8	18	36	18	8	88		1	8	16	28	20	8	80
2	6	10	22	20	6	64		2	4	14	20	20	12	70
3	8	12	28	22	10	80		3	8	12	30	18	10	78
4	4	8	14	16	6	48		4	8	14	28	18	10	78
5	6	6	12	14	6	44		5	8	12	20	22	12	74
6	4	6	12	12	6	40		6	6	10	26	20	10	72
7	4	12	24	16	8	64		7	8	12	30	20	12	82
8	4	8	12	14	10	48		8	4	14	16	20	10	64
9	6	10	24	16	10	66		9	4	10	26	12	8	60
10	8	8	20	20	12	68		10	4	8	12	10	6	40
11	6	10	22	20	10	68		11	4	8	12	8	6	38
12	8	10	30	16	12	76		12	8	18	24	20	8	78
13	4	8	18	16	10	56		13	8	10	24	14	10	66
14	8	8	26	16	12	70		14	8	14	28	18	10	78
15	4	6	22	10	6	48		15	8	12	14	20	10	64
TOTAL	88	140	322	246	132	928		TOTAL	98	184	338	260	142	1022

Table 5. Quality scenarios in Spanish and American games (I=Identification; N=Narrative; C=Contents; G=Gameplay; D=Didactics)

The preliminary findings of the quality assessment reveal that overall American games score higher than Spanish in all dimensions. However, it can also be observed that the best individual score is received by a Spanish game and the worst by an American game.

8.3. Exploring mediation models in the study of video game effects

Scholars argue that serious games can be an effective tool to increase people's attitudes and behaviors. In respond to the need to further identify which variables may moderate the effectiveness of games in this sense, we have started to explore the effects of playing a game on behavioral intentions testing self-efficacy as the moderated mediating mechanism, based on the Theory of Planned Behavior (TPB) by Ajzen (2002). In addition, we intend to address the relationship between playing a game, enjoyment and self-efficacy to fully understand how different playing experiences can influence self-efficacy, by analyzing the responses of those adolescents who interacted with *2020 Energy*. The mechanism through which this process occurs is that playing a game can

lead to a state of enjoyment or flow, "where players are extremely concentrated and time passes unnoticed", which can lead to a higher awareness of important issues involved in the game, and in effect, to a positive change in attitude, which can subsequently trigger a change in behavior itself (Soekarjo & van Oostendorp, 2015). Based on literature review and previous empirical studies, we initiated a study that aims to explore the following hypothesis and proposed mediation models

1) Unless people believe that they can produce desired effects by their actions, they have little incentive to act for behavior change; then we hypothesize that: *playing a game leads to self-efficacy, which in turn has a positive effect on behavioral intentions* (H1)

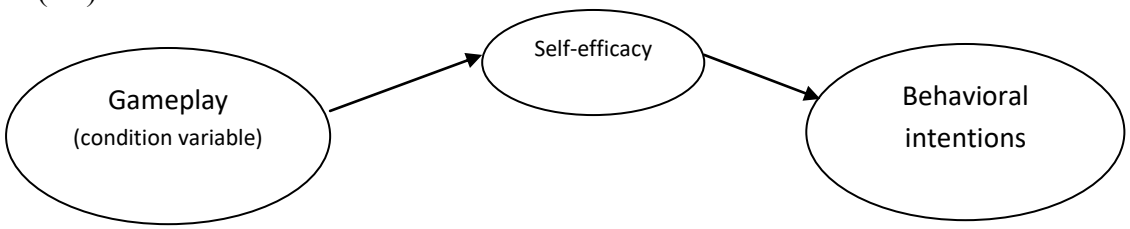


Figure 9. Proposed mediation model for experimental and control group.

2) If a videogame produces enjoyment (*positive affective state), an optimal brain activation occurs that can lead to a* positive change in attitudes; then, we hypothesize that *playing a game leads to enjoyment, which in turn has a positive effect on self-efficacy* (H2).

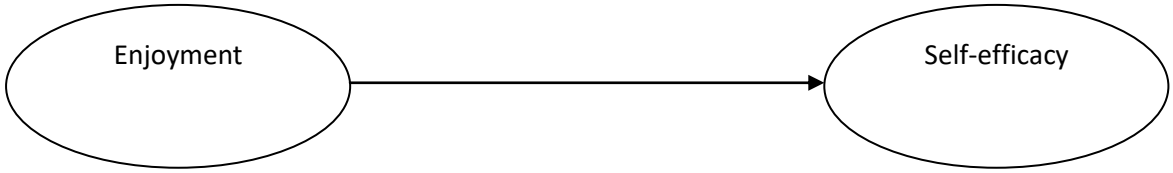


Figure 10. Proposed mediation model for experimental group only.

Preliminary results are not currently available; these analyses are in process.

8.4. Framework for climate change engagement through serious games: a proposal of game attributes

How to design a good game that is able to engage youth, creating a personal state of connection with the issue of climate change? In relation to some of the recommendations and statements on future research lines open up by this thesis, we initiated a study that aims to empirically investigate which attributes a climate change game should have in order to have the most impact on users´ engagement at the cognitive, emotional and behavioral levels.

The study takes a qualitative and interpretative approach to data collection and analysis: grounded theory was used to develop a framework for climate change engagement through serious games "grounded" on data collected through semi-structured interviews with key experts to identify the game attributes. Those findings were further

corroborated by a group discussion with teenagers (consensus validity) and supported by literature review (content validity).

*Interviews: criteria for the selection of experts were: a) they are involved in developing climate change games or b) they are well-known game designers and scholars. In total 12 experts from the United States were interviewed, five females and seven males from the United States: two of them work for federal agencies (EPA, NOAA), one for a scientific magazine (National Geographic), one for an NGO (Red Cross Red Crescent Climate Center), two for research centers (Wilson Center, Virginia Serious Games Institute-GMU), and six for game design companies (Legacy Games, Game Lab, Sense of Wonder, Persuasive Games, Schell Games, Wyvern). Most of the experts have been involved in developing games on climate change or sustainability issues (Disaster Hero, Recycle City, SimCityEDU, Decisions for the Decade, Paying for predictions, Act to Adapt, Windfall, Where the Rivers Meet the Sea, and Plant it Green). The twelve semi-structured interviews were undertaken in May and June 2016; they were carried out face to face, or by telephone/email when meeting in person was not possible. The average interview took 40 minutes to complete, with the range spanning from 30 minutes to 50 minutes. All the interviews were recorded and transcribed immediately. Interview transcripts were reviewed by the researchers and subjected to two rounds of summary and reduction.

*Group discussion: with the aim of validating the results from the interviews -by checking for agreement and consensus-, we proceeded with data triangulation using a group discussion with 17 students aged from 12 to 18. We chose young people because they are the target group of most climate changes games that are being developed. Participants worked well together because they were classmates at a game design course. The session took place during one of their scheduled classes. One of the researchers acted as a moderator, with support from the teacher, introducing the objectives and explaining how the discussion should proceed before asking participants to imagine that they were working for a game design company, and in this scenario, their company was asked to make a serious game about climate change. They had to brainstorm, discuss and write down game attributes that would engage the player, create an emotional investment, and inspire the player to make changes in their real life based on what they learned in the game. The students wrote additional gaming attributes that could be added to assist these three criteria, and they continued sharing their ideas with their classmates.

Figure 11. Photos taken during the group discussion

The process of grounded theory started with data collection, gradually building up categories –exploratory phase- and then forming a theory before corroborating and linking it to the literature – theorizing and validating phase- (Figure 9). This process is not lineal since interpretative research is characterized by circular structures in which the analysis requires to return and revise the data every time in order to strengthen the classifications.

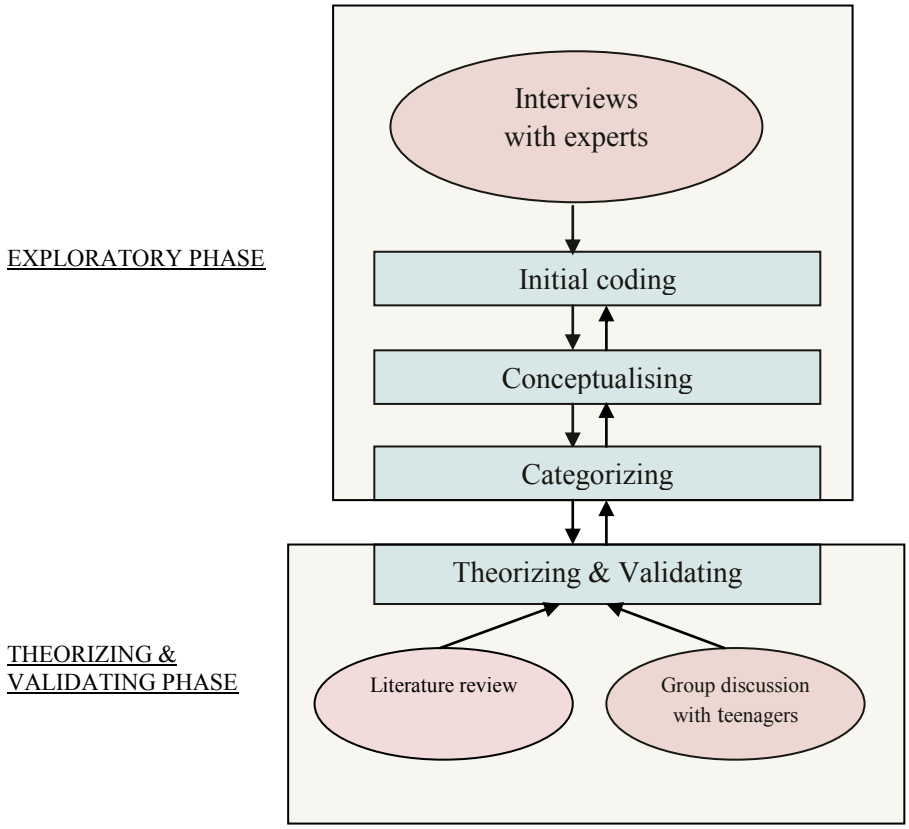


Figure 12. Methodological approach in this study.

The resulting 15 core categories represent the proposal of game attributes by the interviewees (Table 7).

- ***Achievable:*** accomplishment, feasible
- ***Challenging:*** challenge, problem
- ***Concrete***: attention on gameplay, simplicity
- ***Credible:*** concepts, experts
- ***Efficacy-enhancing***: confidence, sense of control
- ***Experiential learning:*** desired uncertainty, focused goals, subconscious
- ***Feedback-oriented:*** feedback
- ***Fun:*** fun, addictive
- ***Identity-driven***: aesthetics, characters, culture, tailored
- ***Leveling-up:*** levels, ramp-up
- ***Meaningful:*** impactful, proximity
- ***Narrative-driven***: fantasy, storytelling

- ***Reward-driven:*** rewards
- ***Simulating***: associations, choices, complexity, effects, imitation, puzzle
- ***Social***: community, hybrid-reality, media, pressure

Table 7. Core categories –accompanied by their concepts- proposed as game attributes

Once the game attributes were identified, we proceeded to accommodate them into the three dimensions of engagement proposed by Lorenzoni et al. (2007):

- Cognitive involvement: what people think and know, and how much mental effort they are willing to exert.
- Emotional involvement: what and how strongly people feel about climate change.
- Behavioral involvement: what and how much people do to address climate change.

The following integrative diagram shows the different categories developed and the relationship between them in the attempt to generate an exploratory theory about climate change engagement through serious games (Figure 10). As can be observed, some interviewees found out difficulties in separating game attributes into three different dimensions, since all of these three phenomena occur simultaneously in a game. That is the reason why some of the attributes fall into two or all the dimensions.

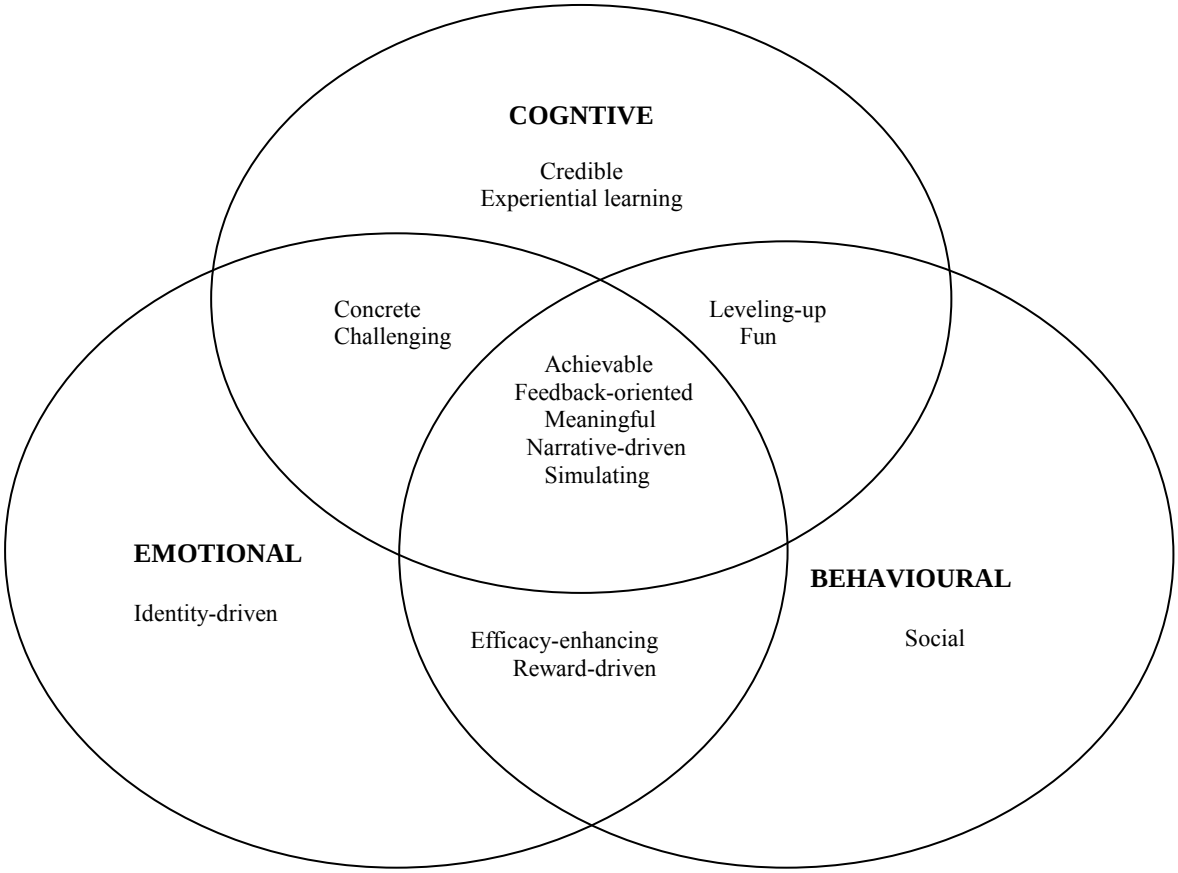


Figure 13. Framework of Climate Change Engagement through Serious Games

The framework suggests that, in order to develop serious games on climate change, designers should try to appeal, not only to the analytical processing system, but overall to the experiential system, playing with reality by creating imaginary worlds and highlighting powerful and emotive narratives about climate change that connect with youth´ values and personal experiences, paying careful attention to both verbal, written and audiovisual communication. An engaging game should be fun and should let the players work hard towards clear and achievable goals, connecting concrete actions with concrete consequences, moving through the game at their own pace, providing them with positive evaluations and making them feel good, important or empowered, whether they act in utopian or dystopian scenarios, representing the good guys or the bad guys. When social interaction and peer pressure take places, there are greater chances to extrapolate actions from the virtual to the real world, building a social movement. The proposed framework can offer new insights, lay out the foundation for future work and be used by game developers for designing climate change games and by scholars for analyzing the potential of games in maximizing cognitive, emotional and behavioral engagement.

REFERENCES

Ajzen, I. (2002). Perceived control, self-efficacy, locus of control, and the theory of planned behavior. *Journal of Applied Social Psychology*, *32*, 107-122. doi:10.1111/j.1559-1816.2002.tb00236.x

DEV. (2015). Libro blanco del desarrollo español de videojuegos (The white book of the development of Spanish video games). Madrid, Spain: Author.

Lorenzoni I, Nicholson-Colen S, & Whitmarsh L. Barriers perceived to engaging with climate change among the UK public and their policy implications. *Global Environmental Change*, 2007; 17(3-4):445-459.

Soekarjo M., & van Oostendorp H. (2019). Measuring Effectiveness of Persuasive Games Using an Informative Control Condition. *International Journal of Serious Games*, 2(2), 6-20.

APPENDIX 1: COVER LETTER TO EXPERTS PARTICIPATING IN THE DELPHI METHOD

The use of the Delphi method to define criteria for evaluating online games focusing on climate change contents

Problem definition:
The suitability of a tool for evaluating online games focusing on climate change contents, which is validated by a multidisciplinary and international panel of experts, that allows docents in particular, and society in general, to assess the communicational and educational potential of available games on Internet about this topic.

Objective:
1) To define criteria that reach consensus for evaluating ecological games focusing on climate change contents based on the judgments of a panel of experts, with the final aim of 2) designing a validated tool for the evaluation of these types of games.

Methodological approach:
Delphi method, a structured process and interactive forecasting method to collect opinions that establish consensus, based on the experiences and judgments of experts.

Methodological process:
The starting point is the existence of a research problem that requires a group of experts whose knowledge and experience are considered appropriate to reach the objective of the study. The facilitator of the technique selects a group of experts and develops the consulting rounds. In our case, we propose a Delphi technique with three rounds to the selected experts, starting with open questions and concluding with a more structured and closed questionnaire.

1) The first consulting round is open and spontaneous, asking two similar questions to everyone, once they have received the preliminary evaluation file based on literature review:

- To what extent do you consider it necessary to take into account a validated tool for evaluating games focusing on climate change contents?
- Which indicators are missing in this preliminary evaluation file?

2) The second consulting round consists of a questionnaire where experts assess in ordinal terms (high, medium, low) the evaluation indicators of the preliminary evaluation file, aiming at identifying common and conflicting viewpoints and achieving a first consensus in the first selection of evaluation criteria.

3) Finally, a questionnaire that allows experts positioning themselves with a numerical scale (1-3), from their respective expertise areas, in those criteria that have reached more consensus in the previous round, with the aim of calculating a mean scores and determine the results.

The experts will receive a report with the final answers.

PRELIMINARY EVALUATION FILE

DIMMENSION 1: Identification

-name of the game
-URL
-location on the web (independent website, section of a website...)
-existence of a mobile application
-language
-genre (simulation, puzzle, quiz,…)
-description/summary

DIMMENSION 2: Enunciation

-name of producer/author
-type of producer/author (Government, NGO, private sector...)
-producer/author positioning (committed, neutral,...)
-communicative objectives
-target audience
-enunciation marks

DIMMENSION 3: Narratology

-narrative format
-global storyline/plot
-chapter or level storyline/plot
-representation of the character/avatar
-role of the character (scientists, politician, business manager,...)
-competences of the character (must do vs. want to do)
-representation of the environment
-dimension/space (global, local,...)
-dimension/time (past, present, future)
-concepts used (climate change, global warming,…)
-existence of false concepts-mistakes
-use of explicit scientific concepts
-use of explicit explicative/descriptive texts
-use of explicit information sources (press, IPCC reports...)
-convergence with social networks (facebook, twitter,...)
-climate change perspective (mitigation, adaptation)
-main topic (energy efficiency, waste management, consumption…)
-actions promoted
-message frame/context: causes
-message frame/context: consequences
-message frame/tone (alarmist, positive,…)
-images used

DIMMENSION 4: Ludology

-gameplay tipology (open, closed)
-number of players
-use (individual, collective...)
-type of player (explorer, competitor...)
-timing
-levels
-game mission/ final objectives (who wins)
-game mission/instrumental objectives
-game dynamics
-game mechanics
-game components
-rewards system
-feedback system
-availability of game instructions (walkthrough)

DIMMENSION 5: Didactics

-competencies
-abilities
-problem resolution style
-interdisciplinarity
-areas of knowledge/ curricular adaptation
-need of previous knowledge
-existence of docents and teachers guidelines

APPENDIX 2: PROTOCOL FOR CODERS

A continuación se presenta el protocolo para la evaluación de juegos online sobre temática de cambio climático; información contextual y conjunto de normas que guían la interpretación del corpus para efectuar el registro de datos de la forma más adecuada para su tratamiento estadístico; y la propia ficha de evaluación para el registro de datos.

Libro de códigos: guía para la interpretación del corpus

Sobre la ficha de evaluación

Para evaluar la muestra de juegos se hace uso de la ficha de evaluación. Una ficha de evaluación o de análisis es una plantilla para el registro de datos, semejante a un cuestionario de encuesta; si concluida la aplicación de una encuesta, hay tantos cuestionarios rellenos como encuestados hayan respondido a las preguntas que contiene, en nuestro caso al concluir el registro de datos, habrá tantas fichas de evaluación rellenadas como juegos hayan sido evaluados.

La ficha de evaluación para la recogida de información está inspirada en el modelo de "análisis de videojuegos como discurso" de Pérez-Latorre: en este modelo se integran una visión del juego narratologista, que entiende este medio como una forma de narrativa y de generar historias, así como una visión ludologista, que tiene en cuenta la retórica que oculta el diseño de las dinámicas, mecánicas y elementos del juego. Además, se añade una visión pedagógica, con el fin de evaluar su potencial educativo de cara a su introducción en el aula. En la ficha de evaluación se distinguen:

- Dimensiones
- Criterios de evaluación / variables
- Opciones de respuesta / valores

Las dimensiones sirven de guía para clasificar los criterios de evaluación. Así, los criterios de evaluación quedan divididos en 5 dimensiones- identificación, narrativa, análisis de contenido, jugabilidad y didáctica:

Identificación	Rasgos que ayudan a identificar y localizar al juego. Ej: nombre, URL, emplazamiento en la web, idioma, productor, edad, género del juego, finalidad comunicativa-educativa
Narrativa	Análisis de las estructuras narrativas, estudio del juego como narración y como contexto en el que se establecen las condiciones para producir el mensaje. Ej: existencia de un narrador, *storyline*, representación del personaje, representación del entorno
Contenidos	Análisis del contenido del juego y los mensajes que se transmiten, el cual puede revelarse a través de textos, audios, imágenes estáticas e imágenes dinámicas. Ej: conceptos empleados, uso explícito de fuentes de información, convergencia con redes sociales, tema principal, contexto, tono del mensaje
Jugabilidad	Análisis de las estructuras lúdicas del juego; estudio del juego como juego, en función de mecánicas, y de cómo su diseño produce significado. Ej: número de jugadores, duración, niveles, misión del juego, dinámicas, mecánicas y elementos
Didáctica	Análisis del juego como recurso didáctico; estudio de los elementos pedagógicos y educativos. Ej: competencias y habilidades, áreas de conocimiento, acompañamiento de guía docente

Los criterios de evaluación (variables) son los elementos a analizar en cada uno de los juegos online. A continuación, se presentan los criterios de evaluación y se define cada uno de ellos para su correcta interpretación:

IDENTIFICACIÓN		
Criterio de evaluación	**Definición del criterio**	**Fuente**
Nombre del juego		
URL	Página web	
Emplazamiento en la web	La URL puede estar emplazada en una página web independiente, en una sección de la página web del productor/autor o en una sección de otra página web. Este criterio permite valorar su visibilidad online	
Disponibilidad de aplicación para móviles	El juego online puede disponer de una versión para móviles a través de una aplicación. En este caso, la página web incluye o informa sobre la opción de descarga de la aplicación	
Gratuidad	Se refiere a si el juego es gratuito o de pago	
Género del juego	Clasificación del juego en función de sus mecánicas y su finalidad: *Juego de acción/ aventura: juegos donde la narrativa adquiere protagonismo; jugadores navegan en mundos complejos, superando desafíos para alcanzar un gol. *Juego de habilidad / puzle: jugadores tiene que solventar pruebas o enigmas para progresar en el juego; la pantalla suele ser estática y están basados en estrategia. Ej: laberintos, tiro al blanco *Juego de plataforma: jugadores se mueven en ambientes donde tienen que progresar sobre plataformas. Ej: Mario Bross *Juego de tablero: adaptación a juegos de tablero *Juego de cartas: adaptación a juegos de cartas *Juego de preguntas / quizz: los jugadores ponen a prueba sus conocimientos a través de preguntas *Juego de simulación: jugadores se hacen pasar por un personaje; controlan mundos simulados, pueden modificar entorno. Ej: SimCity, SIMS *Juego publicitario / advergame: juego que promociona un producto, marca u organización *Mini-juegos: conjunto de pruebas como quizz, puzle, etc. Cada modalidad de juego tiene el mismo nivel de importancia.	European SchoolNet, 2009; Lacasa 2011
Idioma	Lengua o lenguas que se emplean en el juego	Reckien and Eisenack, 2013
Nombre del productor/autor	Entidad encargada de la autoría y producción del juego. Ejemplo: Junta de Andalucía, Greenpeace, IBM. No confundir con entidad financiadora (en este caso, se puede indicar entre paréntesis).	
Tipo de productor/autor	Tipo de entidad encargada de la autoría y producción del juego.	Katsaliaki, 2014; Reckien and Eisenack, 2013
Público objetivo	Público al que está dirigido el juego, en función a intervalos de edad y nivel educativo, ya sea infantil, primaria, secundaria o para todos los públicos	Katsaliaki and Mustafee, 2014; Reckien and Eisenack, 2013
Finalidad comunicativa	Se refiere a intencionalidad y objetivos comunicativos que persigue el juego. Desde el objetivo más simple al más complejo, los objetivos pueden ser: desarrollar familiaridad sobre el tema; impulsar conocimiento sobre causas y consecuencias; fomentar cambio de actitudes y comportamientos; y/o estimular reflexiones y pensamiento crítico. Cuanto más complejo el juego, mayor complejidad en su finalidad comunicativa.	Moser, 2011
Breve descripción del juego	Resumen del juego en función a su productor-destinatario, género, objetivos y contenidos	

NARRATIVA		
Criterio de evaluación	**Definición del criterio**	**Fuente**
Relevancia de la narrativa	Los elementos narrativos pueden adquirir importancia o ser irrelevante/ abstractos	Lacasa 2011; Latorre, 2010
Existencia de un narrador	El mediador que relata hechos. No confundir con el sistema de retroalimentación o feedback. Todos los juegos tienen un sistema de feedback, pero no todos tienen narrador.	Lacasa 2011; Latorre, 2010
Historia global	Descripción del relato del juego en su conjunto, basado en la sucesión lógica o causal de hechos por un tiempo determinado	Lacasa 2011; Latorre, 2010
Representación del personaje	Descripción de las características y cualidades del personaje-avatar. Ejemplo: estatus, ánimo, experiencia. En algunos casos será irrelevante.	Lacasa 2011; Latorre, 2010
Rol del personaje-jugador	Función o cargo que desempeña el personaje-jugador dentro de la historia. Ejemplo: científico, político, empresario	Katsaliaki, 2014; Lacasa 2011; Latorre, 2010
Representación del entorno	Descripción del mundo en el que se desenvuelve el personaje-jugador	Lacasa 2011; Latorre, 2010
Dimensión-espacio	Contexto general de los escenarios que aparecen en el juego. Example: global, nacional, regional, local	Lacasa 2011; Latorre, 2010; Meira-Cartea, 2007; Reckien and Eisenack, 2013
Dimensión-tiempo	Periodo en el tiempo en el que transcurre la historia y en el que el personaje-jugador actúa. Ejemplo: pasado, presente, futuro	Lacasa 2011; Latorre, 2010; Meira-Cartea, 2007; Reckien and Eisenack, 2013
CONTENIDOS		
Criterio de evaluación	**Definición del criterio**	**Fuente**
Conceptos más empleados	Terminología que más se usa en el juego para describir el fenómeno que estudiamos (explicar cada opción de respuesta)	
Uso explícito de conceptos científicos o conceptos relacionados	Definición de términos y conceptos en relación al tema. Ej: energías renovables, gases de efecto invernadero, etc.	León, 2013
Uso explícito de fuentes de información	Se cita la fuente de información y datos. Ejemplo: informes IPCC, periódicos, páginas web	León, 2013; Piñuel-Raigada et al., 2009
Convergencia con redes sociales	Se incluyen enlaces a redes sociales. Ejemplo: Facebook o Twitter	
Marco del mensaje- enfoque sobre cambio climático	El contenido se centra en acciones de: *mitigación al cambio climático: acciones orientadas a la disminución de gases de efecto invernadero. Ej: movilidad sostenible; gestión de energía; gestión de residuos; consumo sostenible; fomento de sumideros de carbono *adaptación al cambio climático: acciones orientadas a reducir el impacto de los efectos adversos, creando defensas ante ellos. Ej: adaptación sectores productivos primarios; adaptación del turismo; urbanismo y construcción; adaptación salud humana; control de recursos hídricos; finanzas/seguros; protección de los sistemas naturales y biodiversidad; seguridad frente eventos extremos ; estilo de vida individual *ambas	Moser, 2011
Marco del mensaje-temática principal	El juego puede centrar su contenido en …	
Marco del mensaje- promoción de acciones	El contenido del juego promueve a través de sus mensajes acciones a nivel colectivo o individual para concienciar al jugador.	

Marco del mensaje-contextualización: causas	El contenido del juego expone causas del problema en cuestión	
Marco del mensaje-contextualización: consecuencias	El contenido del juego expone consecuencias del problema en cuestión	
Marco del mensaje-tono	Se refiere a cómo se transmite el mensaje, a los valores y emociones que se le otorga al tema abordado. Acompañar las opciones de respuesta con frases literales que sirvan de ejemplo	León, 2013; Meira-Cartea, 2007; Moser, 2011
Imágenes empleadas	Imágenes estáticas (fotografías) e imágenes dinámicas (animaciones, vídeos)	León, 2013; Moser, 2011
JUGABILIDAD		
Criterio de evaluación	**Definición del criterio**	**Fuente**
Número de jugadores		Katsaliaki and Mustafee, 2014
Uso individual o colectivo	Mientras que una simulación permite un uso individual, un juego de preguntas permite un uso colectivo	European SchoolNet, 2009
Tipo de jugador	El juego puede encajar en distintos perfiles de jugador: *Creador: preferencia por construir, diseñar, crear, personalizar, escoger *Competidores: preferencia por ganar, comparar, desafiar *Exploradores: preferencia por descubrir, coleccionar, revisar, votar *Colaboradores: preferencia por comentar, compartir, dar, compartir con otros, formar comunidad	Kim, 2012
Duración	Se refiere al tiempo empleado por nivel-misión o durante todo el juego; especificar ambos si procede	European SchoolNet, 2009
Interactividad	Grado de intervención, modificación y elección sobre el contenido por parte del usuario; puede ser alto, medio o bajo. Nivel alto suele corresponderse con juegos más complejos como simulaciones y nivel bajo con juegos más simples como los juegos de habilidad	Grifeau, 2012
Misión del juego- objetivos finales	Se refiere a las acciones esenciales para ganar el juego. Responde a la pregunta "¿cómo se gana el juego?	Katsaliaki and Mustafee, 2014; Latorre, 2010
Dinámicas del juego (*)	Estructura general del juego, elementos que provocan la inmersión del jugador. Ejemplo: fantasía, altruismo, descubrimiento	Werbach, 2012
Mecánicas del juego	Reglas y retos que propone el juego. Ejemplo: toma de decisiones, recolección de objetos, retención de memoria, puntería, etc. Especificar recursos empleados. Ejemplo: quizz para toma de decisiones, laberintos para recolectar objetos, emparejar imágenes para retención de memoria, juegos de habilidad para puntería, etc.	Latorre, 2010; Werbach, 2012
Sistema de recompensas	Este criterio evalúa las acciones que se incentivan (ej: apagar luces, desmantelar central nuclear), así como las propias recompensas (Ej: monedas virtuales, alimentos virtuales, etc.)	Latorre, 2010
Sistema de feedback	Comentarios (texto, audio, audiovisual) que recibe el jugador ante determinadas acciones. Pueden ser positivos o negativos (o ambos), es decir, puede bonificar o penalizar las acciones del jugador.	European SchoolNet, 2009; Latorre, 2010
Disponibilidad de instrucciones del juego	Guía interna o en pdf que nos indica paso por paso las acciones que debemos llevar a cabo para avanzar en un juego	Katsaliaki and Mustafee, 2014
Posibilidad de guardar la partida	Posibilidad de guardar la partida y reiniciarla cuando se desee	European SchoolNet, 2009

(*) Las dinámicas, mecánicas y componentes están inter-relacionados. Así, para provocar una dinámica específica (ej: desafío), habrá que emplear las mecánicas (ej: retos, competición) a través de determinados recursos (ej: carreras) y componentes (ej: niveles, equipos, distintivos) acordes para transmitir esa sensación. El resultado sería: niveles, equipos, distintivitos→ retos, competición→ desafío. Otro ejemplo: avatares→ personalización→ sensación, emoción

DIDÁCTICA		
Criterio de evaluación	**Definición del criterio**	**Fuente**
Competencias	Conocimientos y actitudes que alcanza el estudiante. Ejemplo: competencia en comunicación lingüística, competencia matemática, competencia artística y cultural, etc.	LOMCE, 2015
Habilidades	Operaciones mentales que alcanza el estudiante. Se trata de una pirámide que va de la habilidad más simple a la más compleja. Así, para llegar a la última habilidad, se tendrá que haber pasado por las anteriores: *Recordar: reconocer o traer de vuelta conocimiento de la memoria. La memoria se usa para producir definiciones, recitar material, unir imágenes iguales. Acciones relacionadas: repetir, nombrar, reconocer, relacionar, enumerar, saber *Comprender: construir significado desde distintos tipos de mensajes. Acciones relacionadas: interpretar, clasificar, resumir, inferir, compara, explicar, diferenciar, inferir *Aplicar: implementar mensajes aprendidos a través de productos como presentaciones o simulaciones. Acciones relacionadas: aplicar, relacionar, desarrollar, usar, operar, ilustrar, calcular *Analizar: dividir conceptos en partes, determinando como las partes se relacionan entre sí o con la estructura. Acciones relacionadas: organizar, atribuir, diferenciar, probar, examinar, contrastar, investigar, deducir, experimentar, descubrir, separar *Evaluar: desarrollar juicios basados en criterios a través de comprobaciones. Acciones relacionadas: componer, preparar, predecir, modificar, planear, establecer, documentar, combinar, relacionar, construir, proponer *Crear: poner elementos juntos para producir algo nuevo o sintetizar elementos en algo diferente. Acciones relacionadas: producir, juzgar, valorar, criticar, considerar, estimar, decidir, escoger, medir, concluir,	Blooom, 1956
Condiciones de resolución de problemas	Tipo de razonamiento para resolver problemas: razonamiento reproductivo (memoria) o productivo (creatividad)	Lacasa 2011; Latorre, 2010
Necesidad de conocimientos previos	Esta necesidad se verá influenciada por el nivel de dificultad del juego	
Curva de aprendizaje	Nivel de dificultad en el aprendizaje	European SchoolNet, 2009
Posibilidad de trabajo en grupo	Se refiere a la posibilidad de formar grupo de estudiantes en torno a los ordenadores ante la posible escasez de ordenadores en el aula	European SchoolNet, 2009
Accesibilidad	Disponibilidad del juego para estudiantes con diversidad funcional	European SchoolNet, 2009
Interdisciplinariedad	Combinación de dos o más disciplinas académicas, áreas de conocimiento; está relacionado con la adaptación curricular	
Acompañamiento de guía didáctica	Documento o enlace a información destinada a los docentes con consejos y sugerencias para implementarlo en el aula	
Posibilidad de evaluación del docente	El docente puede acceder a historial de acciones, registro de intervenciones, etc.	European SchoolNet, 2009; Katsaliaki and Mustafee, 2014

Como se puede observar, hay una gran variedad de criterios de evaluación o variables; la ficha recoge tanto variables cuantitativas (número de ocurrencias de categorías), como cualitativas (presencia o ausencia de categorías). Atendiendo a las opciones de respuesta o valores de las variables cualitativas, encontramos variables dicotómicas (dos valores) y policotómicas (más de dos valores); y según su escala de medición, nos encontramos con variables ordinales (ej: alto, medio, bajo) y variables nominales (sin criterio de orden).

Cómo rellenar las fichas de análisis

Aunque el videojuego no esté diseñado con fines comunicativos o educativos explícitos, y aunque los jugadores no suelan participar en los juegos con prioridades comunicativas, es posible estudiar la significación de todo tipo de videojuegos.

El evaluador debe de ponerse en el papel de un docente cuando evalúa la dimensión de didáctica, en el papel de un diseñador de juegos cuando evalúa la dimensión de jugabilidad o en el papel de un periodista crítico cuando evalúa la dimensión de contenidos. Aunque el análisis de los juegos demanda la implicación interpretativa del analista, pero debe estar siempre bien anclada en las propiedades formales de la obra.

Los juegos suelen estar divididos en unidades procesuales o *gameplays*; éstas pueden ser niveles, misiones o episodios. Consideraremos las *gameplays* como nuestras unidades de análisis, del mismo modo que en una película puede ser una secuencia o en un cómic un *strip-frame*. El contenido y los mensajes se suelen manifestar, por ejemplo, a través de las presentaciones de los juegos, diálogos de personajes, comentarios de los narradores, notas informativas, preguntas de los quizzes, etc.

A medida que se está jugando, el evaluador tendrá que ir registrando los datos de cada *gameplay*. Puesto que hay que prestar atención a criterios de evaluación de diversa índole, desde los mensajes hasta el diseño del juego, será necesario jugar varias partidas o repetir niveles/misiones/episodios tantas veces como sea necesario para registrar los datos de manera adecuada. Es aconsejable tener una hoja aparte para tomar anotaciones para cada *gameplay*, pues sólo hay una ficha de evaluación por juego que recopilará la información de todas las *gameplays.*

El análisis es cuantitativo y cualitativo, es decir, nos interesa hacer un recuento de los datos para sacar información estadística (ej: un 60% de los juegos usan un tono alarmista en sus mensajes), sin embargo, también nos interesa respaldar toda la información estadística con ejemplos (ej: el narrador: "nada podrá impedir que la capa de ozono desaparezca"). Por lo tanto, el evaluador deberá de tomar anotaciones extra, como frases literales o comentarios de los personajes, narradores, etc.

Otras observaciones

Codificar las fichas de la siguiente manera: T_ficha de evaluacion_Alerta CO2 (T de Tania); la ficha de evaluación incluye al final una sección de "Notas extras", donde podemos incluir comentarios, reflexiones, u otros contenidos importantes, como los objetivos literales que aparecen en la introducción del juego o definiciones. En esta sección también incluimos las 5 capturas de imagen más relevantes/curiosas con un pie de foto; si es necesario escribimos las opciones de respuesta en horizontal; la ficha de evaluación contiene opciones de respuesta única o multi-respuesta. Los casos de multi-respuesta están señalados en la ficha. En estos casos, ponemos las respuestas en negrita; cuando se pide ejemplos, aportamos como máximo 5 ejemplos.

Ficha

Identification

1. Game title:
2. URL (website):
3. Location on the web
(e.g.: Accionatura >> explora>> iniciativas>>educación>>juego alertaco2)
   - Independent website
   - Section of the producer/author website: _____
   - Section of another website: _____
4. Existence of a mobile app
   - Yes
   - No
5. Free of charge
   - Yes
   - No
6. Language
   - Only Spanish (o other official languages in Spain)
   - Only English
   - Spanish & English
   - Spanish & English & other language options: _____
7. Type of producer: (who is the producer?)
   - National Government
   - Regional Government (state level)
   - Provincial Government (county level)
   - Local Government (city level)
   - Collaborations: _____
   - Private sector (companies, insurance)
   - Educative institutions
   - Communication media
   - Universities/research centers
   - Other: _____
   - Scientific institutions
   - NGOs
   - Intergovernmental institutions
8. Target audience
   - < 6 years
   - < 12 years / elementary school
   - >12 years / secondary school
   - >18 years
   - All publics
9. Communicative purpose
(multiple-choice)
   - Develop familiarity with the topic (general information)
   - Promote knowledge on causes and consequences (lineal relations)
   - Promote attitude and behavior change
   - Promote reflections, critical thinking, development of ideas and solutions
10. Brief description (game genre, objectives and contents):

_____

Narrative

11. Relevance of narrative
   - High
   - Medium
   - Low
12. Existence of narrator
   - Yes (who?): _____
   - No
13. Global storyline: _____
14. a) Character depiction:
14. b) Character role
   - Scientist
   - Politician
   - Entrepreneur
   - Major
   - Superheroes
   - Citizen
   - Farmer
   - Other: energy promoter
15. Representation of the environment:
16. a) Dimension-space
   - Real
   - Fictitious
   - Global
   - National
   - Regional
   - Local
   - Several:
   - Scenarios/ places: _____
16. b) Dimension-time
   - Past
   - Present
   - Future
   - Several:

Contents

17. Terms used
Climate change Global warming Both Any
18. Presence of false concepts and mistakes (e.g.: acid rain, tsunami, ozone depletion,…)
Yes: _____ No
19. Explicit use of scientific concepts
(if climate change, global warming or greenhouse effect is define, write the literal definition in "extra notes")
Yes: _____ No
20. Explicit use of information sources (e.g.: press, IPCC reports, websites, movies, …)
Yes: _____ No
21. Convergence with social networks
Yes: _____ No
22. a) Message frame- climate change focus
Mitigation Adaptation Both
22. b) Message frame- main themes
(multiple-choice: maximum 4)

Energy	Natural disasters
Water (saving, scarcity,..)	Biodiversity
Waste management (recycling,…)	Citizen participation
Transport y mobility	Urban planning
Carbon sink (oceans, forests,…)	Primary sector (agriculture, farming, fishing…)
Consumption	Industrial sector
International negotiations	Service sector (commerce, tourism …)
Other: _____	

22. c) Message frame – promotion of actions
(both at the individual and collective level)
_____

22. d). Message frame- causes
It does not present
Natural causes
Human action: (what?) _____
Both (natural and human)
22. e) Message frame- consequences
(multiple-choice: maximum 4)

It does not present	Extreme weather events	Health (diseases…)
Glacial melting	Sea level rise	Political (wars...)
Desertification	Temperature rise	Economic (crisis…)
Other: _____	Threat to ecosystems	Social (migrations…)

22. f) Message frame- style
Positive (it presents mostly solutions, shows good)
Negative (it presents mostly problems, shows conflict and situation getting worse)
Neutral (it presents problems and solutions in a balanced manner)
22. g) Message frame- tone
(multiple-choice: maximum 4)

Alarmist	Informative	Protest	Hope /encouraging	Directness	Ethical/moral
Sensationalist	Uncertainty	Conflictive	Pro-action	Distance	Humorous

Examples:

23. Images (save image captures)

Gameplay

24. Nº of players:
25. Use
Individual Collective Both
26. Type of player
Collaborator Explorer Competitor Creator
27. Timing
Less than 30 min. More than 30 min. More than 1hour
28. Degree of interactivity
High Medium Low
29. Game mission- final objectives (how to win, how many levels?):

30. a) Game dynamics
(multiple-choice: maximum 4)

Comradeship	Expression	Progression	Status
Fantasy	Pastime	Ability	
Challenge	Discovery	Emotions	Other:_____
Other: _____			

31. Reward system
No
Yes
what actions are rewarded? _____
what are the rewards?_____

Score system (high scores, leader boards); Experience point system (level up, develop your avatar); Item granting system (virtual items that have social comparison value); Resources (virtual items that have practical game use, such as virtual coins or extra life); Achievement system (titles that are bound to specific avatars or player accounts and are earned by fulfilling certain conditions); Feedback messages (positive feedback displayed); Unlocking mechanisms (gaining access to new content, levels, new areas only after fulfilling certain criteria)

32. Feedback system
Positive: _____
Negative: _____
Both: _____

33. Walkthrough
(availability of guidance, both on the web or pdf)
Yes No

34. Possibility of saving the game
Yes No

Didactics

35. Competences
(multiple-choice: maximum 4)
Linguistics competence
Mathematics competence
Knowledge and interaction with the physical world competence
Information management and digital competence
Social and citizen competence
Cultural and artistic competence
Learning to learn competence
Autonomy and personal initiative

36. Abilities
Remember
Understand
Apply
Analyze
Evaluate
Create

37. Problem resolution conditions
Reproductive reasoning (memory)
Productive reasoning (creativity)
Both

38. Need of previous knowledge
Yes
No

39. Level of difficulty
High
Medium
Low

40. Possibility of group work
Yes
No

41. Accessibility
Yes (how?):
No

42. Interdisciplinary
Yes
No

43. Existence of didactic guidelines
    Yes
    No
44. Possibility of evaluation by teacher
    Yes (how?):
    No

EXTRA NOTES AND IMAGES CAPTURES

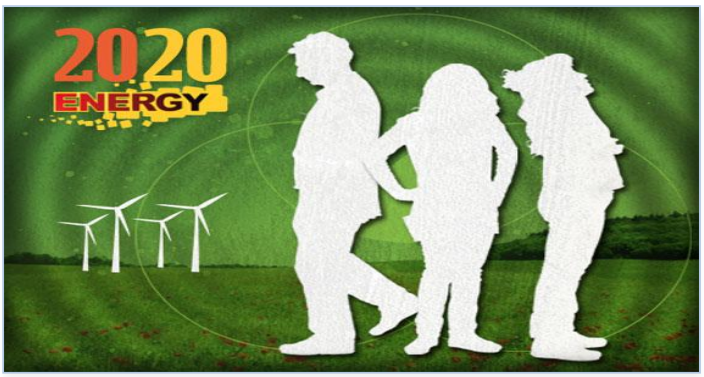
APPENDIX 3: INFORMATIVE LETTER FOR TEACHERS

INFORMATION ABOUT THE PROJECT

- Name of the researcher: Tania Ouariachi Peralta
- Study program: Ph.D Program in Social Sciences at University of Granada (Spain) / Fulbright visiting scholar at the George Mason University- Center for Climate Change Communication at George Mason University
- Academic supervisor in Spain: Dr. María Dolores Olvera Lobo and Dr. José Gutiérrez-Pérez; Academic supervisor in the USA: Dr. Edward Maibach

The research project proposed here is part of a larger doctoral thesis entitled *Gamification as a strategic educommunication tool for climate change: online games for youth.* The objective of this project is to analyze to what extent the use of an online game in class might trigger a change of awareness, understanding, and attitudes towards a certain topic, in this case, climate energy efficiency. The idea is to have one group of students playing the educational online game *Energy 2020* in class (experimental group) and another group without playing (control group), and answer about 5 minutes worth of climate change knowledge and attitudes questions before and immediately after playing/not playing. The experience should be educational and interesting to students and can be completed in a single class period. The same intervention has been carried out successfully in a class in Spain. Having the chance of implementing the same intervention in the USA will allow us to compare results between two different countries and cultures, and assess the viability of gaming strategies.

1- DESIGN OF THE INTERVENTION



The game *Energy 2020 (*http://www.2020energy.eu/en*)* is a serious and educative online game on energy efficiency, renewable energy and sustainable development. It has been chosen, among other reasons, for its feasibility to be used in class: short duration, easy use through quiz questions, possibility of evaluation, possibility of playing in couples in case of shortage of computers, and possibility of a guided itinerary for teachers, who can choose the missions that better fit their curriculum.

The game was produced with the financial support of Intelligent Energy Europe (European Commission) in the framework of the Energy-Bits project, a European multimedia program aiming at creating awareness among youth about energy consumption.

Energy 2020 offers a perspective for debate and adds to traditional learning, which it couldn't replace:

- The game offers complex questioning on the issues of efficiency and the reduction of our energy consumption, renewable energies and sustainable development.
- It holds a comprehensive selection of information and key concepts.
- By anchoring the training in reality, the game makes concepts lively.

Scenario:

For more than a century people have been using and depleting energy resources carefree, as if they were endless. In 2020 the world could find itself in a deadlock. The player has the power to go back in time and to rewrite history.

The player's objective: to reduce the consumption of energy, increase energy efficiency and choose the best renewable energies. He finds help with 3 advisers: economical, environmental, social, but it is up to the player to take the good decisions to improve our collective future!

2- IMPLEMENTATION OF THE INTERVENTION

Two different classes/groups will take part of the intervention: one group will play the game during a single class period (for instance during Earth Day), while the other group will not play the game (control condition). The instrument to gather data is a test that measures their awareness, knowledge and attitudes in relation to climate and energy issues. This test will not only serve for research purposes, but it can be used by teachers as evaluation methods. The intervention will take place in April, any day as convenient for the teachers, and the planning will be the following:

1. All students complete an online pre-test (5 min.) around two weeks before playing (experimental group) / not playing the game (control group). Students in the experimental group will not be informed about the game they will play in the upcoming week.

Pre-test for experimental group
Pre-test for control group

2. During a single class period, one group of students (experimental group), play the game during class (30 min.), complete an online post-test (5 min.) and finish with a quick group discussion (5 min.). Another group of students (control group) do not play the game and just fill in the post-test.

Post-test for experimental group
Post-test for control group

In summary:

GROUP 1: (2 weeks in advance) pre-test → GAMEPLAY → post-test
GROUP 2: (2 weeks in advance) pre-test → NO GAMEPLAY →post-test

*Any pertinent authorization and ethical considerations will be taken into account
*Students privacy will be maintained
*Further instructions will be provided to the teachers
*Results from the tests will be shared with the teacher

APPENDIX 4: SURVEY

Dear student,
Please read the instructions for each section carefully and answer the best you can. Keep in mind that this is for research purposes only and your teachers will not see your personal answers, so we ask you to be very sincere. Please, choose the response that is closest to your opinion. Your point of view is very important. Your answers will help to better understand what students around the world think about climate and energy issues. Thank you very much for your collaboration!

Full name: _____

1. Age: _____ Nationality:_____

2. Gender:

O Female
O Male
O Other

3. How often do you play videogames?

O I never play
O Almost every day, less than one hour
O Every day, between one and two hours
O Every day, more than two hours
O Generally, only weekends and holidays less than two hours
O Generally, only weekends and holidays more than two hours

4. Do you know any videogame on environmental issues (water, waste, energy, climate, forests)?

Yes (Which one?):
No

5. Are you worried about climate change?

Not at all
A little
Quite a lot
A lot

6. Mark with X:

	Yes	No	I do not know
Climate change is happening now			
There is connection between climate change and the increasing emission of greenhouse gasses to the atmosphere that results from some human activities			
There is connection between the increasing emission of greenhouse gasses to the atmosphere and the production and use of energy in our homes and businesses			

	Yes	No
I am aware of the impact of my actions and lifestyle on the environment		
I know the right behaviors to conserve energy or do not use energy at all		
I know measures and products to use energy in a more efficient way, allowing us to do not waste energy		

7. a) Give 2 examples of individual behaviors that helps to conserve energy or do not use energy at all (e.g.: turning off lights while I am not in my bedroom)

_____

b) Give 2 examples of measures or products that help to use energy in a more efficient way, allowing use to do not waste energy (e.g. using incandescent lamps)

_____

8. You think climate change is caused by …

- Mostly by things people do
- Equally by things people do and by natural causes
- Mostly by natural causes

9. Which of the following activities produce greenhouse gasses?
(Multiple-choice: choose as many answers as you want)

- Electricity production
- Traveling by car, boat or plane
- Product distribution
- Washing, drying and ironing clothes
- Traffic jams
- Heating at home
- Meat production
- Food importation
- Waste burial at rubbish dumps
- Deforestation
- I do not know

10. Do you think natural resources will always be available, thanks to scientific and technological progress?

- Not at all
- A little
- Quite a lot
- A lot

11. Sustainable development requires adopting measures in the following areas:
(Multiple-choice: choose as many answers as you want)

- Social
- Economic
- Environmental

12. Which of the following energy sources are considered clean and more environmental friendly? (Multiple-choice: choose as many answers as you want)

- solar
- wind
- natural gas
- biomass
- coal
- hydraulic
- geothermal
- oil
- tidal
- I do not know

13. Do you know what a “passive house” is?

- yes
- no

If yes, can you explain it? _____

14. It is very difficult for me to act to reduce the effects of climate change:

Totally disagree
Tend to disagree
Tend to agree
Totally agree

15. I intend to save energy by…
(Multiple-choice: choose as many answers as you want)

… moving by public transport (bus, train)
…moving by bicycle
… turning off lights
… turning off computers instead of stand-by
…shopping for local products
… growing food in gardens
… recycling (plastic, glass, …)
… reusing products (clothes, books, …)
… using low energy products (light bulbs, electrical appliances)
Other: _____
None of them

16. Mark with X:
(1= totally disagree; 2 =tend to disagree; 3 =tend to agree; 4 =totally agree)

	1	2	3	4
I find the game Energy 2020 interesting				
I have had fun playing the game				
Compared to a normal class, I prefer playing a game				
After playing, I am more interested in learning about energy saving and efficiency, and clean energies				
I would recommend this game to friends				

17. Assess the game: (How did you feel when playing? Did you like playing in pairs? What do you remember the most? What would you add or improve in the game?)

APPENDIX 5: RESPONSES TO SURVEY

PRETEST

SPAIN				Exp. group		Con. group	
CATEGORY	**FACTOR**	**SAMPLE ITEM**	**RESPONSE OPTIONS**	**N**	**%**	**N**	**%**
Identification (only pretest)	Identity						
		1. Age					
		2. Gender	-Female -Male -Other	14 16 0	46,7 53,3 0,0	18 10 0	64,3 35,7 0
		3. Country	-Spain -USA	30 27		28 23	
	Frequency of videogame playing	4. How often do you play videogames?	-I never play	1	3,3	10	35.7
			-Almost every day, less than one hour	5	16,7	4	14.3
			-Every day, between one and two hours	2	6,7	1	3.6
			-Every day, more than two hours	4	13,3	1	3.6
			-Generally, only weekends and holidays less than two hours	11	36,7	5	17.8
			-Generally, only weekends and holidays more than two hours	7	23,3	7	25.0
		5. Do you know any environmental videogame?	-Yes	21	70,0	9	32,1
			-No	9	30,0	19	67,9
Awareness	Concern about climate change	6. Are you worried about climate change?	-Not at all	3	10.0	3	10.7
			-A little	12	40.0	11	39.3
			-Quite a lot	12	40.0	11	39.3
			- A lot	3	10.0	3	10.7
	Risk perception and linkages	7. a) Climate change is happing now…	-Yes	16	53.3	25	89.3
			-No	4	13.3	1	3.6
			-I do not know	10	33.3	2	7.1
		7. b) There is connection between production and use of energy and increasing emission of greenhouse gasses to the atmosphere	-Yes	11	36.7	14	50.0
			-No	0	0	3	10.7
			-I do not know	19	63.3	11	39.3
		7. c) There is connection between the increasing emission of greenhouse gasses to the atmosphere and climate change	-Yes	17	56.7	14	50.0
			-No	1	3.3	1	3.6
			-I do not know	12	40.0	13	46.4
	Self-awareness	8. a) I am aware of the impact of my actions and lifestyle on the environment	-Yes	25	83.3	28	100.0
			-No	5	16.7	0	0
		8. b) I know the right behaviors to conserve energy or do not use energy at all	-Yes	26	86.7	25	89.3
			-No	4	13.3	3	10.7

		8. c) I know measures and products to use energy in a more efficient way, allowing us to not waste energy	-Yes	17	56.7	22	78.6
			-No	13	43.3	6	21.4
	Testing self-awareness	9. a) Provide 2 examples of behavior that helps to save energy					
		9. b) Provide 2 examples of measures or technologies to use energy in a more efficient way					
Knowledge	Attribution of responsibility	10. You think climate change is caused by …	-Mostly by things people do	21	70.0	19	67.9
			-Equally by things people do and by natural causes	7	23.3	5	17.9
			- Mostly by natural causes	2	6.7	4	14.3
		11. Which of the following activities produce greenhouse gasses?	-Electricity production (yes/no)	9	30.0	13	46.4
				21	70.0	15	53.6
			-Traveling by car, boat or plane (yes/no)	16	53.3	23	82.1
				14	46.7	5	17.9
			-Product distribution (yes/no)	3	10.0	2	7.1
				27	90.0	26	92.9
			-Washing, drying and ironing clothes (yes/no)	1	3.3	5	17.9
				29	96.7	23	82.1
			-Traffic jams (yes/no)	23	76.7	22	78.6
				7	23.3	6	21.4
			-Heating at home (yes/no)	9	30.0	19	67.9
				21	70.0	9	32.1
			-Meat production (yes/no)	1	3.3	3	10.7
				29	96.7	25	89.3
			-Food importation (yes/no)	2	6.7	3	10.7
				28	93.3	25	89.3
			-Waste burial at rubbish dumps (yes/no)	13	43.3	11	39.3
				17	56.7	17	60.7
			-Deforestation (yes/no)	14	46.7	23	82.1
				16	53.3	5	17.9
			-I do not know (yes/no)	4	13.3	0	0
				26	86.7	28	100.0
	Understanding o technological progress	12. Do you think natural resources will always be available, thanks to scientific and technological progress?	-Not at all	4	13.3	9	32.1
			-A little	18	60.0	13	46.4
			-Quite a lot	3	10.0	5	17.9
			-A lot	5	16.7	1	3.6
	Understanding on sustainable development	13. Sustainable development requires adopting measures in the following areas:	-Social	3	10.0	0	0
			-Economic	2	6.7	1	3.6
			-Environmental	10	33.3	9	32.1
			-Social and Economic	1	3.3	1	3.6

			-Social and Environment	7	23.3	10	35.7
			-Economic and Environmental	4	13.3	4	14.3
			-Social, Economic and Environmental	3	10.0	2	7.1
			-None of them	0	0	1	3.6
	Understanding on energy sources	14. Which of the following energy sources are considered clean?	-Solar (yes/no)	28	93.3	24	85.7
				2	6.7	4	14.3
			-Wind (yes/no)	15	50.0	22	78.6
				15	50.0	6	21.4
			-Natural Gas (yes/no)	17	56.7	9	32.1
				13	43.3	19	67.9
			-Biomass (yes/no)	9	30.0	10	35.7
				21	70.0	18	64.3
			-Coal (yes/no)	5	16.7	0	0
				25	83.3	28	100.0
			-Hydraulic (yes/no)	14	46.7	23	82.1
				16	53.3	5	17.9
			-Geothermal (yes/no)	4	13.3	12	42.9
				26	86.7	16	57.1
			-Oil (yes/no)	1	3.3	0	0
				29	96.7	28	100.0
			-Tidal (yes/no)	7	23.3	7	25.0
				23	76.7	21	75.0
			-I do not know (yes/no)	1	3.3	1	3.6
				29	96.7	27	96.4
	Attention to glossary of terms	15. Do you know what a “passive house” is? If you know what a “passive house” is, please explain	-Yes	1	3.3	10	35.7
			-No	29	96.7	18	64.3
Attitude	Self-efficacy	16. It is very difficult for me to act to reduce the effects of climate change…	-Totally disagree	7	23.3	12	42.9
			-Tend to disagree	11	36.7	14	50.0
			-Tend to agree	11	36.7	2	7.1
			-Totally agree	1	3.3	0	0
	Behavioral Intentions	17. I intend to save energy by…	-Moving by public transport (yes/no)	8	26.7	20	71.4
				22	73.3	8	28.6
			-Moving by bicycle (yes/no)	4	13.3	8	28.6
				26	86.7	20	71.4
			-Turning off lights (yes/no)	25	83.3	26	92.9
				5	16.7	2	7.1
			-Turning off computers (yes/no)	25	83.3	23	82.1
				5	16.7	5	17.9
			-Shopping for local products (yes/no)	15	50.0	5	17.9
				15	50.0	23	82.1

			-Growing food in gardens (yes/no)	12	40.0	11	39.3
				18	60.0	17	60.7
			-Recycling (yes/no)	25	83.3	20	71.4
				5	16.7	8	28.6
			-Reusing products (yes/no)	23	76.7	16	57.1
				7	23.3	12	42.9
			-Using low energy products (yes/no)	21	70.0	12	42.9
				9	30.0	16	57.1
			-None of them (yes/no)	1	3.3	0	0
				29	96.7	28	100.0

USA				Exp. group		Con. Group	
CATEGORY	**FACTOR**	**SAMPLE ITEM**	**RESPONSE OPTIONS**	**N**	**%**	**N**	**%**
Identification (only pretest)	Identity						
		1. Age					
		2. Gender	-Female -Male -Other	15 11 1	55,6 40,7 3,7	13 10 0	56,5 43,5 0
		3. Country	-Spain	30		28	
			-USA	27		23	
	Frequency of videogame playing	4. How often do you play videogames?	-I never play	9	33,3	7	30,4
			-Almost every day, less than one hour	6	22,2	2	8,7
			-Every day, between one and two hours	0	0	2	8,7
			-Every day, more than two hours	1	3,7	0	0
			-Generally, only weekends and holidays less than two hours	9	33,3	7	30,4
			-Generally, only weekends and holidays more than two hours	2	7,4	5	21,7
		5. Do you know any environmental videogame?	-Yes	5	18,5	5	21,7
			-No	22	81,5	18	78,3
Awareness	Concern about climate change	6. Are you worried about climate change?	-Not at all	2	7.4	1	4.3
			-A little	10	37.0	11	47.8
			-Quite a lot	5	18.5	3	13.0
			- A lot	10	37.0	8	34.8
	Risk perception and linkages	7. a) Climate change is happing now…	-Yes	26	96.3	22	95.7
			-No	0	0	0	0
			-I do not know	1	3.7	1	4.3
		7. b) There is connection between production and use of energy and increasing emission of greenhouse gasses to the atmosphere	-Yes	19	70.4	21	91.3
			-No	0	0	0	0
			-I do not know	8	29.6	2	8.7

		7. c) There is connection between the increasing emission of greenhouse gasses to the atmosphere and climate change	-Yes	23	85.2	21	91.3
			-No	0	0	0	0
			-I do not know	4	14.8	2	8.7
	Self-awareness	8. a) I am aware of the impact of my actions and lifestyle on the environment	-Yes	26	96.3	23	100.0
			-No	1	3.7	0	0
		8. b) I know the right behaviors to conserve energy or do not use energy at all	-Yes	21	77.8	18	78.3
			-No	6	22.2	5	21.7
		8. c) I know measures and products to use energy in a more efficient way, allowing us to not waste energy	-Yes	13	48.1	17	73.9
			-No	14	51.9	6	26.1
	Testing self-awareness	9. a) Provide 2 examples of behavior that helps to save energy					
		9. b) Provide 2 examples of measures or technologies to use energy in a more efficient way					
Knowledge	Attribution of responsibility	10. You think climate change is caused by …	-Mostly by things people do	18	66.7	19	82.6
			-Equally by things people do and by natural causes	8	29.6	4	17.4
			- Mostly by natural causes	1	3.7	0	0
		11. Which of the following activities produce greenhouse gasses?	-Electricity production (yes/no)	16	59.3	15	65.2
				11	40.7	8	34.8
			-Traveling by car, boat or plane (yes/no)	23	85.2	21	91.3
				4	14.8	2	8.7
			-Product distribution (yes/no)	13	48.1	13	56.5
				14	51.9	10	43.5
			-Washing, drying and ironing clothes (yes/no)	7	25.9	9	39.1
				20	74.1	14	60.9
			-Traffic jams (yes/no)	16	59.3	16	69.6
				11	40.7	7	30.4
			-Heating at home (yes/no)	17	63.0	15	65.2
				10	37.0	8	34.8
			-Meat production (yes/no)	8	29.6	9	39.1
				19	70.4	14	60.9
			-Food importation (yes/no)	17	63.0	15	65.2
				10	37.0	8	34.8
			-Waste burial at rubbish dumps (yes/no)	19	70.4	15	65.2
				8	29.6	8	34.8
			-Deforestation (yes/no)	19	70.4	15	65.2
				8	29.6	8	34.8
			-I do not know	3	11.1	1	4.3

			(yes/no)	24	88.9	22	95.7
	Understanding on technological progress	12. Do you think natural resources will always be available, thanks to scientific and technological progress?	-Not at all	7	25.9	8	34.8
			-A little	15	55.6	13	56.5
			-Quite a lot	4	14.8	2	8.7
			-A lot	1	3.7	0	0
	Understanding on sustainable development	13. Sustainable development requires adopting measures in the following areas:	-Social	0	0	0	0
			-Economic	0	0	0	0
			-Environmental	2	7.4	2	8.7
			-Social and Economic	0	0	0	0
			-Social and Environment	0	0	0	0
			-Economic and Environmental	5	18.5	6	26.1
			-Social, Economic and Environmental	20	74.1	15	65.2
			-None of them	0	0	0	0
	Understanding on energy sources	14. Which of the following energy sources are considered clean?	-Solar (yes/no)	26	96.3	21	91.3
				1	3.7	2	8.7
			-Wind (yes/no)	24	88.9	20	87.0
				3	11.1	3	13.0
			-Natural Gas (yes/no)	12	44.4	8	34.8
				15	55.6	15	65.2
			-Biomass (yes/no)	4	14.8	6	26.1
				23	85.2	17	73.9
			-Coal (yes/no)	1	3.7	0	0
				26	96.3	23	100.0
			-Hydraulic (yes/no)	8	29.6	8	34.8
				19	70.4	15	65.2
			-Geothermal (yes/no)	11	40.7	7	30.4
				16	59.3	16	69.6
			-Oil (yes/no)	0	0	0	0
				27	100.0	23	100.0
			-Tidal (yes/no)	9	33.3	9	39.1
				18	66.7	14	60.9
			-I do not know (yes/no)	0	0	2	8.7
				27	100.0	21	91.3
	Attention to glossary of terms	15. Do you know what a “passive house” is? If you know what a “passive house” is, please explain	-Yes	1	3.7	3	13.0
			-No	26	96.3	20	87.0
Attitude	Seflf-efficacy	16. It is very difficult for me to act to reduce the effects of climate change…	-Totally disagree	1	3.7	6	26.1
			-Tend to disagree	12	44.4	11	47.8
			-Tend to agree	13	48.1	6	26.1
			-Totally agree	1	3.7	0	0
	Behavioral	17. I intend to save	-Moving by public	8	29.6	3	13.0

	intentions	energy by…	transport (yes/no)	19	70.4	20	87.0
			-Moving by bicycle (yes/no)	13	48.1	8	34.8
				14	51.9	15	65.2
			-Turning off lights (yes/no)	26	96.3	21	91.3
				1	3.7	2	8.7
			-Turning off computers (yes/no)	20	74.1	16	69.6
				7	25.9	7	30.4
			-Shopping for local products (yes/no)	8	29.6	11	47.8
				19	70.4	12	52.2
			-Growing food in gardens (yes/no)	4	14.8	1	4.3
				23	85.2	22	95.7
			-Recycling (yes/no)	22	81.5	20	87.0
				5	18.5	3	13.0
			-Reusing products (yes/no)	16	59.3	16	69.6
				11	40.7	7	30.4
			-Using low energy products (yes/no)	16	59.3	15	65.2
				11	40.7	8	34.8
			-None of them (yes/no)	0	0	0	0
				27	100.0	23	100.0

POSTTEST

SPAIN (N=30)				Exp. group		Con. Group	
CATEGORY	**FACTOR**	**SAMPLE ITEM**	**RESPONSE OPTIONS**	**N**	**%**	**N**	**%**
Awareness	Concern about climate change	6. Are you worried about climate change?	-Not at all	0	0	1	3.6
			-A little	12	40,0	8	28.6
			-Quite a lot	16	53,3	18	64.3
			- A lot	2	6,7	1	3.6
	Risk perception	7. a) Climate change is happing now…	-Yes	22	73,0	20	71,4
			-No	3	10,0	3	10,7
			-I do not know	5	16,7	5	17,9
		7. b) There is connection between production and use of energy and increasing emission of greenhouse gasses to the atmosphere	-Yes	17	56,7	8	28,6
			-No	1	3,3	4	14,3
			-I do not know	12	40,0	16	57,1
		7. c) There is connection between the increasing emission of greenhouse gasses to the atmosphere and climate change	-Yes	20	66,7	19	67,9
			-No	1	3,3	0	0
			-I do not know	9	30,0	9	32,1
	Self-awareness	8. a) I am aware of the impact of my actions and	-Yes	28	93,3	26	92,9

		lifestyle on the environment	-No	2	6,7	2	7,1
		8. b) I know the right behaviors to conserve energy or do not use energy at all	-Yes	27	90,0	24	85,7
			-No	3	10,0	4	14,3
		8. c) I know measures and products to use energy in a more efficient way, allowing us to not waste energy	-Yes	22	73,3	23	82,1
			-No	8	26,7	5	17,9
	Testing self-awareness	9. a) Provide 2 examples of behavior that helps to save energy					
		9. b) Provide 2 examples of measures or technologies to use energy in a more efficient way					
Knowledge	Attribution of responsibility	10. You think climate change is caused by …	-Mostly by things people do	21	70,0	19	67.9
			-Equally by things people do and by natural causes	9	30,0	8	28.6
			- Mostly by natural causes	0	0	1	3.6
		11. Which of the following activities produce greenhouse gasses?	-Electricity production (yes/no)	9	30,0	12	42,9
				21	70,0	16	57,1
			-Traveling by car, boat or plane (yes/no)	20	66,7	22	78,6
				10	33,3	6	21,4
			-Product distribution (yes/no)	5	16,7	7	25,0
				25	83,3	21	75,0
			-Washing, drying and ironing clothes (yes/no)	3	10,0	6	21,4
				27	90,0	22	78,6
			-Traffic jams (yes/no)	22	73,3	21	75,0
				8	26,7	7	25,0
			-Heating at home (yes/no)	14	46,7	20	71,4
				16	53,3	8	28,6
			-Meat production (yes/no)	1	3,3	5	17,9
				29	96,7	23	82,1
			-Food importation (yes/no)	5	16,7	7	25,0
				25	83,3	21	75,0
			-Waste burial at rubbish dumps (yes/no)	13	43,3	14	59,0
				17	56,7	14	50,0
			-Deforestation (yes/no)	10	33,3	16	57,1
				20	66,7	12	42,9
			-I do not know (yes/no)	5	16,7	2	71,
				25	83,3	26	92,9
	Understanding on technological progress	12. Do you think natural resources will always be available, thanks to scientific and technological progress?	-Not at all	7	23,3	5	17,9
			-A little	11	36,7	13	46,4
			-Quite a lot	10	33,3	9	32,1
			-A lot	2	6,7	1	3,6
	Understanding on sustainable development	13. Sustainable development requires adopting measures in the following areas:	-Social	2	6,7	1	3,6
			-Economic	3	10,0	2	7,1
			-Environmental	5	16,7	11	39,3
			-Social and Economic	1	3,3	2	7,1
			-Social and Environment	0	0	4	14,3
			-Economic and Environmental	4	13,3	2	7,1
			-Social, Economic and Environmental	15	50,0	5	17,9

			-None of them	0	0	1	3,6
	Understanding on energy sources	14. Which of the following energy sources are considered clean?	-Solar (yes/no)	26	86,7	27	96,4
				4	13,3	1	3,6
			-Wind (yes/no)	19	63,3	20	71,4
				11	36,7	8	28,6
			-Natural Gas (yes/no)	17	56,7	7	25,0
				13	43,3	21	75,0
			-Biomass (yes/no)	4	13,3	16	57,1
				26	86,7	12	42,9
			-Coal (yes/no)	1	3,3	1	3,6
				29	96,7	27	96,4
			-Hydraulic (yes/no)	16	53,3	19	67,9
				14	46,7	9	32,1
			-Geothermal (yes/no)	6	20,0	13	46,4
				24	80,0	15	53,6
			-Oil (yes/no)	0	0	0	0
				30	100,0	28	100,0
			-Tidal (yes/no)	5	16,7	7	25,0
				25	83,3	21	75,0
			-I do not know (yes/no)	3	10,0	1	3,6
				27	90,0	27	96,4
	Attention to glossary of terms	15. Do you know what a "passive house" is? If you know what a "passive house" is, please explain	-Yes	3	10,0	8	28,6
			-No	27	90,0	20	71,4
Attitude	Self-efficacy	16. It is very difficult for me to act to reduce the effects of climate change…	-Totally disagree	9	30,0	11	39.3
			-Tend to disagree	15	50,0	16	57.1
			-Tend to agree	6	20,0	1	3.6
			-Totally agree	1	3,3	0	0
	Behavioral intentions	17. I intend to save energy by…	-Moving by public transport (yes/no)	11	36,7	16	57,1
				19	63,3	12	42,9
			-Moving by bicycle (yes/no)	16	53,3	12	42,9
				14	46,7	16	57,1
			-Turning off lights (yes/no)	30	100,0	26	92,9
				0	0	2	7,1
			-Turning off computers (yes/no)	23	76,7	22	78,6
				7	23,3	6	21,4
			-Shopping for local products (yes/no)	12	40,0	11	39,3
				18	60,0	17	60,7
			-Growing food in gardens (yes/no)	12	40,0	11	39,3
				18	60,0	17	60,7
			-Recycling (yes/no)	25	83,3	21	75,0
				5	16,7	7	25,0
			-Reusing products (yes/no)	19	63,3	16	57,1
				11	36,7	12	42,9
			-Using low energy products (yes/no)	18	60,0	15	53,6
				12	40,0	13	46,4
			-None of them (yes/no)	0	0	0	0
				30	100,0	28	100,0
Interaction with the game **(only posttest)**	Game assessment	18. a) I find the game Energy 2020 interesting	-Totally disagree	0	0		
			-Tend to disagree	2	6,7		
			-Tend to agree	10	33,3		
			-Totally agree	18	60,0		
		18. b) I have had fun playing the game	-Totally disagree	0	0		
			-Tend to disagree	2	6,7		
			-Tend to agree	10	33,3		
			-Totally agree	18	60,0		
		18. c) Compared to a normal class, I prefer playing a game	-Totally disagree	0	0		
			-Tend to disagree	6	20,0		
			-Tend to agree	12	40,0		
			-Totally agree	12	40,0		
		18. d) After playing, I am more interested in learning about energy saving and efficiency,	-Totally disagree	1	3,3		
			-Tend to disagree	8	26,7		
			-Tend to agree	15	50,0		

		and clean energies	-Totally agree	6	20,0
		18. e) I would recommend this game to friends	-Totally disagree	1	3,3
			-Tend to disagree	2	6,7
			-Tend to agree	5	16,7
			-Totally agree	22	73,3
		19. Give your opinion about the game			

USA				Exp. group		Con. Group	
CATEGORY	**FACTOR**	**SAMPLE ITEM**	**RESPONSE OPTIONS**	**N**	**%**	**N**	**%**
Awareness	Concern about climate change	6. Are you worried about climate change?	-Not at all	0	0	0	0
			-A little	11	40,7	9	39,1
			-Quite a lot	8	29,6	8	34,8
			- A lot	8	29,6	6	26,1
	Risk perception	7. a) Climate change is happing now…	-Yes	27	100	21	91,3
			-No	0	0	0	0
			-I do not know	0	0	2	8,7
		7. b) There is connection between production and use of energy and increasing emission of greenhouse gasses to the atmosphere	-Yes	24	88,9	20	87,0
			-No	1	3,7	0	0
			-I do not know	2	7,4	3	13,0
		7. c) There is connection between the increasing emission of greenhouse gasses to the atmosphere and climate change	-Yes	24	88,9	21	91,3
			-No	0	0	0	0
			-I do not know	3	11,1	2	8,7
	Self-awareness	8. a) I am aware of the impact of my actions and lifestyle on the environment	-Yes	26	96,3	21	91,3
			-No	1	3,7	2	8,7
		8. b) I know the right behaviors to conserve energy or do not use energy at all	-Yes	23	85,2	20	87,0
			-No	4	14,8	3	13,0
		8. c) I know measures and products to use energy in a more efficient way, allowing us to not waste energy	-Yes	23	85,2	19	82,6
			-No	4	14,8	4	17,4
	Testing self-awareness	9. a) Provide 2 examples of behavior that helps to save energy					
		9. b) Provide 2 examples of measures or technologies to use energy in a more efficient way					
Knowledge	Attribution of responsibility	10. You think climate change is caused by …	-Mostly by things people do	18	66,7	20	87,0
			-Equally by things people do and by natural causes	9	33,3	3	13,0
			- Mostly by natural causes	0	0	0	0
		11. Which of the following activities produce greenhouse gasses?	-Electricity production (yes/no)	16	59.3	18	78.3
				11	40.7	5	21.7
			-Traveling by car, boat	24	88.9	19	82.6

			or plane (yes/no)	3	11.1	4	17.4
			-Product distribution (yes/no)	17	63.0	21	91.3
				10	37.0	2	8.7
			-Washing, drying and ironing clothes (yes/no)	14	51.9	12	52,2
				13	48.1	11	47,8
			-Traffic jams (yes/no)	22	81.5	17	73.9
				5	18.5	6	26.1
			-Heating at home (yes/no)	22	81.5	17	73,9
				5	18.5	6	26,1
			-Meat production (yes/no)	9	33.3	13	56.5
				18	66.7	10	43.5
			-Food importation (yes/no)	17	63.0	19	82.6
				10	37.0	4	17.4
			-Waste burial at rubbish dumps (yes/no)	17	63.0	16	69.6
				10	37.0	7	30.4
			-Deforestation (yes/no)	17	63.0	10	43.5
				10	37.0	13	56.5
			-I do not know (yes/no)	1	3.7	0	0
				26	96.3	23	100,0
	Understanding on technological progress	12. Do you think natural resources will always be available, thanks to scientific and technological progress?	-Not at all	8	29,6	7	30,4
			-A little	15	55,6	11	47,8
			-Quite a lot	3	11,1	5	21,7
			-A lot	1	3,7	0	0
	Understanding on sustainable development	13. Sustainable development requires adopting measures in the following areas:	-Social	1	3,7	0	0
			-Economic	0	0	1	4,3
			-Environmental	0	0	1	4,3
			-Social and Economic	0	0	0	0
			-Social and Environment	0	0	0	0
			-Economic and Environmental	0	0	2	8,7
			-Social, Economic and Environmental	26	100,0	19	82,6
			-None of them	0	0	0	0
	Understanding on energy sources	14. Which of the following energy sources are considered clean?	-Solar (yes/no)	26	96.3	22	95.7
				1	3.7	1	4.3
			-Wind (yes/no)	25	92.6	21	91.3
				2	7.4	2	8.7
			-Natural Gas (yes/no)	15	55.6	8	34.8
				12	44.4	15	65.2
			-Biomass (yes/no)	6	22.2	4	17.4
				21	77.8	19	82.6
			-Coal	3	11.1	0	0

			(yes/no)	24	88.9	23	100,0
			-Hydraulic (yes/no)	12	44.4	9	39.1
				15	55.6	14	60.9
			-Geothermal (yes/no)	10	37.0	9	39.1
				17	63.0	14	60.9
			-Oil (yes/no)	2	7.4	1	4.3
				25	92.6	22	95.7
			-Tidal (yes/no)	13	48.1	12	52.2
				14	51.9	11	47.8
			-I do not know (yes/no)	0	0	1	4.3
				27	100,0	22	95.7
	Attention to glossary of terms	15. Do you know what a "passive house" is? If you know what a "passive house" is, please explain	-Yes	4	14,8	5	21,7
			-No	23	85,2	18	78,3
Attitude	Self-efficacy	16. It is very difficult for me to act to reduce the effects of climate change…	-Totally disagree	5	7,4	2	21,7
			-Tend to disagree	12	40,7	11	52,2
			-Tend to agree	6	44,4	12	26,1
			-Totally agree	0	0	2	7,4
	Behavioral intentions	17. I intend to save energy by..	-Moving by public transport (yes/no)	11	40.7	4	17.4
				16	59.3	19	82.6
			-Moving by bicycle (yes/no)	18	66.7	11	47.8
				9	33.3	12	52.2
			-Turning off lights (yes/no)	26	96.3	23	100,0
				1	3.7	0	0
			-Turning off computers (yes/no)	20	74.1	21	91.3
				7	25.9	2	8.7
			-Shopping for local products (yes/no)	9	33.3	12	52.2
				18	66.7	11	47.8
			-Growing food in gardens (yes/no)	6	22.2	9	39.1
				21	77.8	14	60.9
			-Recycling (yes/no)	25	92.6	22	95.7
				2	7.4	1	4.3
			-Reusing products (yes/no)	18	66.7	17	73.9
				9	33.3	6	26.1
			-Using low energy products (yes/no)	17	63.0	16	69.6
				10	37.0	7	30.4
			-None of them (yes/no)	0	0	0	0
				27	100,0	23	10,0
Interaction with the game **(only posttest)**	Game assessment	18. a) I find the game Energy 2020 interesting	-Totally disagree	1	3,7		
			-Tend to disagree	0	0		
			-Tend to agree	10	37,0		
			-Totally agree	16	59,3		
		18. b) I have had fun playing the game	-Totally disagree	1	3,7		
			-Tend to disagree	0	0		
			-Tend to agree	14	51,9		

			-Totally agree	12	44,4
		18. c) Compared to a normal class, I prefer playing a game	-Totally disagree	1	3,7
			-Tend to disagree	2	7,4
			-Tend to agree	8	29,6
			-Totally agree	16	59,3
		18. d) After playing, I am more interested in learning about energy saving and efficiency, and clean energies	-Totally disagree	0	0
			-Tend to disagree	5	18,5
			-Tend to agree	14	51,9
			-Totally agree	8	29,6
		18. e) I would recommend this game to friends	-Totally disagree	1	3,7
			-Tend to disagree	5	18,5
			-Tend to agree	10	37,0
			-Totally agree	11	40,7
		19. Give your opinion about the game			