Universidad de Alcalá
COMISIÓN DE ESTUDIOS OFICIALES DE POSGRADO Y DOCTORADO

ACTA DE EVALUACIÓN DE LA TESIS DOCTORAL

Año académico 2017/18

DOCTORANDO: **DOMÍNGUEZ DÍAZ, ADRIÁN**
D.N.I./PASAPORTE: ******0990F**

PROGRAMA DE DOCTORADO: **D442-INGENIERIA DE LA INFORMACIÓN Y DEL CONOCIMIENTO**
DPTO. COORDINADOR DEL PROGRAMA: **CIENCIAS DE LA COMPUTACIÓN**
TITULACIÓN DE DOCTOR EN: **DOCTOR/A POR LA UNIVERSIDAD DE ALCALÁ**

En el día de hoy 03/04/18, reunido el tribunal de evaluación nombrado por la Comisión de Estudios Oficiales de Posgrado y Doctorado de la Universidad y constituido por los miembros que suscriben la presente Acta, el aspirante defendió su Tesis Doctoral, elaborada bajo la dirección de **LUIS DE MARCOS ORTEGA // JOSÉ J. MARTÍNEZ HERRÁIZ.**

Sobre el siguiente tema: *APORTACIONES SOBRE EL USO DE GAMIFICACIÓN Y REDES SOCIALES EN LA EDUCACIÓN UNIVERSITARIA: EFECTOS SOBRE EL RENDIMIENTO ACADÉMICO*

Finalizada la defensa y discusión de la tesis, el tribunal acordó otorgar la CALIFICACIÓN GLOBAL[1] de (**no apto, aprobado, notable y sobresaliente**): SOBRESALIENTE

Alcalá de Henares, 3 de Abril de 2018

EL PRESIDENTE

Fdo.: Roberto Barchino

EL SECRETARIO

Fdo.: Antonio Moreira Teixeira

EL VOCAL

Fdo.: Mª Teresa Villalba de Benito

Con fecha 7 de mayo de 2018 la Comisión Delegada de la Comisión de Estudios Oficiales de Posgrado, a la vista de los votos emitidos de manera anónima por el tribunal que ha juzgado la tesis, resuelve:

- [X] Conceder la Mención de "Cum Laude"
- [ ] No conceder la Mención de "Cum Laude"

La Secretaria de la Comisión Delegada

FIRMA DEL ALUMNO,

Fdo.: ADRIÁN DOMÍNGUEZ DÍAZ

[1] La calificación podrá ser "no apto" "aprobado" "notable" y "sobresaliente". El tribunal podrá otorgar la mención de "cum laude" si la calificación global es de sobresaliente y se emite en tal sentido el voto secreto positivo por unanimidad.

Universidad de Alcalá

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DE POSGRADO Y DOCTORADO

En aplicación del art. 14.7 del RD. 99/2011 y el art. 14 del Reglamento de Elaboración, Autorización y Defensa de la Tesis Doctoral, la Comisión Delegada de la Comisión de Estudios Oficiales de Posgrado y Doctorado, en sesión pública de fecha 7 de mayo, procedió al escrutinio de los votos emitidos por los miembros del tribunal de la tesis defendida por *DOMÍNGUEZ DÍAZ, ADRIÁN*, el día 03 de abril de 2018, titulada *APORTACIONES SOBRE EL USO DE GAMIFICACIÓN Y REDES SOCIALES EN LA EDUCACIÓN UNIVERSITARIA: EFECTOS SOBRE EL RENDIMIENTO ACADÉMICO*, para determinar, si a la misma, se le concede la mención "cum laude", arrojando como resultado el voto favorable de todos los miembros del tribunal.

Por lo tanto, la Comisión de Estudios Oficiales de Posgrado **resuelve otorgar** a dicha tesis la

MENCIÓN "CUM LAUDE"

Alcalá de Henares, 8 de mayo de 2018
EL VICERRECTOR DE INVESTIGACIÓN Y TRANSFERENCIA

F. Javier de la Mata de la Mata

Copia por e-mail a:
Doctorando: DOMÍNGUEZ DÍAZ, ADRIÁN
Secretario del Tribunal: ANTÒNIO MOREIRA TEIXEIRA
Director/a de Tesis: LUIS DE MARCOS ORTEGA // JOSÉ J. MARTÍNEZ HERRÁIZ

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Servicio de Estudios Oficiales de Posgrado

DILIGENCIA DE DEPÓSITO DE TESIS.

Comprobado que el expediente académico de D./Dª ADRIÁN DOMÍNGUEZ DÍAZ reúne los requisitos exigidos para la presentación de la Tesis, de acuerdo a la normativa vigente, y habiendo presentado la misma en formato: ☒ soporte electrónico ☐ impreso en papel, para el depósito de la misma, en el Servicio de Estudios Oficiales de Posgrado, con el nº de páginas: 119 se procede, con fecha de hoy a registrar el depósito de la tesis.

Alcalá de Henares a 20 de diciembre de 2017

UNIVERSIDAD DE ALCALÁ SERVICIO DE ESTUDIOS OFICIALES DE POSGRADO

PURIFICACIÓN REVIEJO

Fdo. El Funcionario

Universidad de Alcalá

Departamento de Ciencias de la Computación
Doctorado en Ingeniería de la Información y del Conocimiento

Aportaciones sobre el uso de gamificación y redes sociales en la educación universitaria: Efectos sobre el rendimiento académico

Tesis Doctoral presentada por

ADRIÁN DOMÍNGUEZ DÍAZ

Directores:
Dr. Luis de Marcos Ortega
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Alcalá de Henares, 2017

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HACEN CONSTAR:

Que, una vez concluido el trabajo de tesis doctoral titulado: "**Aportaciones sobre el uso de gamificación y redes sociales en la educación universitaria: Efectos sobre el rendimiento académico**" realizado por D. Adrián Domínguez Díaz, dicho trabajo tiene suficientes méritos teóricos, que se han contrastado adecuadamente mediante validaciones experimentales y que son altamente novedosos. Por todo ello consideran que procede su defensa pública.

Y para que así conste, firman la presente en Alcalá de Henares, a 27 de noviembre de 2017.

El Director de la Tesis	El Codirector de Tesis
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CERTIFICO: Que la Comisión Académica del Programa ha aprobado la presentación de la Tesis Doctoral titulada "Aportaciones sobre el uso de gamificación y redes sociales en la educación universitaria: Efectos sobre el rendimiento académico" realizada por D. ADRIÁN DOMÍNGUEZ DÍAZ, dirigida por el Dr. D. Luis de Marcos Ortega y co-dirigida por el Dr. José Javier Martínez Herraiz.

La Tesis Doctoral reúne los requisitos científicos de originalidad y rigor metodológicos para ser defendida ante un tribunal. Esta Comisión ha tenido también en cuenta la evaluación positiva anual del doctorando, habiendo obtenido las correspondientes competencias establecidas en el Programa.

Y para que así conste, firmo la presente en Alcalá de Henares, a 27 de noviembre de 2017.

Dr. José Javier Martínez Herraiz

Agradecimientos

En primer lugar quiero expresar mi más sincero y profundo agradecimiento al Prof. Luis de Marcos Ortega, director de esta investigación, por su inestimable apoyo durante estos años de trabajo. Gracias a su esfuerzo y dedicación ha sido posible esta tesis. También quiero agradecer a mi subdirector, Prof. José Javier Martínez Herráiz, por depositar en mi toda su confianza desde un comienzo, por su continuo apoyo y asesoramiento y por implicarse tan activamente en que este trabajo saliese adelante.

Quiero mostrar también mi agradecimiento a las distintas personas que de una forma u otra me han apoyado en la elaboración de esta tesis y a lo largo de mi trayectoria como investigador. Entre ellas, quiero dar las gracias a mi amigo y compañero D. Joseba Sáenz de Navarrete, con el que tantos proyectos he compartido, por su importante trabajo en esta investigación. También estoy muy agradecido al Prof. Antonio García Cabot, no solo por su contribución a esta tesis, sino también por haber confiado en mí en distintos momentos clave de mi trayectoria. Asimismo, quiero dar las gracias al Prof. José María Gutiérrez Martínez, por apostar por mi cuando aún era un estudiante universitario y por la importante y positiva influencia que ha tenido en mi carrera desde entonces.

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Resumen

Aportaciones sobre el uso de gamificación y redes sociales en la educación universitaria: Efectos sobre el rendimiento académico

Uno de los retos a los que se enfrenta la educación a distancia es conseguir que los alumnos hagan un uso efectivo de las herramientas y recursos que les ofrece el e-learning y que esto se traduzca en una mejora de sus resultados académicos. Una idea para conseguirlo es hacer más motivador el e-learning mediante gamificación y redes sociales. La gamificación puede entenderse cómo el proceso de mejora de un servicio para que ofrezca al usuario experiencias similares a las de un juego, con el objetivo de que su uso resulte más motivador. Las redes sociales pueden complementar a la gamificación, ofreciendo mecanismos para crear experiencias que fomenten la interacción entre alumnos. En esta tesis se estudia la relación del uso de gamificación y redes sociales con el rendimiento académico de los alumnos en una asignatura universitaria semipresencial. En cada uno de los tres artículos de los que consta esta tesis se presenta un experimento donde se diseña, implementa y evalua un entorno de aprendizaje online basado en el uso de gamificación y/o redes sociales. En ellos se analiza la relación entre el uso de cada instrumento y su efecto en el rendimiento académico, comparándolo con el rendimiento de un grupo de control. Los resultados muestran que la gamificación y las redes sociales pueden tener efecto en el rendimiento, pero que tanto su sentido como su magnitud dependen de diversos factores entre los que se encuentran las necesidades motivacionales de los alumnos o la adecuación de la experiencia a los objetivos de aprendizaje. Se puede concluir que la gamificación no es una solución que se pueda aplicar de forma genérica a cualquier entorno de aprendizaje. Los resultados también sugieren que la combinación de gamificación y redes sociales resulta significativa para los alumnos, existiendo relación entre la posición del usuario dentro de la red social gamificada y su rendimiento académico.

Abstract

Contributions on the use of gamification and social networks in university education: Effects on academic performance

One of the challenges that online education faces is to ensure that students make an effective use of the tools and resources offered by e-learning that translates into an improvement of their academic results. An idea to achieve this is to make e-learning more motivating through gamification and social networks. Gamification can be understood as the process of enhancing a service so that it offers gameful experiences, with the aim of making it more motivating for its users. Social networks can complement gamification, offering mechanisms to create experiences that foster interaction between students. In this dissertation it is studied the relation of gamification and social networks to students' academic performance in a blended university course. The research consists of three papers, each of which presents an experiment where an online learning environment based on the use of gamification and/or social networks is designed, implemented and assessed. In these papers we analyse the relationship between the use of each instrument and its effect on academic performance, comparing it with the performance of a control group. Results show that gamification and social networks can have an effect on performance, but that both its sense and magnitude depend on various factors, such as motivational needs of students or a proper alignment between the design of the experience and the learning objectives. It can be concluded that gamification is not a solution that can be applied in a generic way to any learning environment. Results also suggest that the combination of gamification and social networks is significant for students, showing a relationship between the user's position within the gamified social network and their academic performance.

Índice general

Capítulo 1

Introducción

1.1. Introducción

La gamificación es un término surgido en la década del 2000 y popularizado en 2010 que busca dar nombre a la idea de aplicar determinados aspectos propios del diseño de videojuegos en otro tipo de contextos, normalmente digitales, como forma de influir sobre el comportamiento de sus usuarios. La primera definición académica de la gamificación surge en 2011 y la define como "the use of game design elements in non-game contexts" (Deterding *et al.*, 2011), dejando a un lado el aspecto motivacional de la gamificación en favor de una definición más generalista. Otros autores, sin embargo, han propuesto definiciones alternativas centradas en el uso de la gamificación como mecanismo motivacional, como "the use of game mechanics, dynamics, and frameworks to promote desired behaviors" (Lee *et al.*, 2011) o "a process of enhancing a service with affordances for gameful experiences in order to support user's overall value creation" (Huotari y Hamari, 2017). En línea con estas últimas definiciones, la gamificación ha sido tratada en la práctica como un mecanismo de motivación con el que influir en el comportamiento de las personas. De esta forma, la gamificación sería un concepto aplicable a una gran variedad de campos donde la motivación tenga un papel relevante como el marketing (Huotari y Hamari, 2011), la salud (King *et al.*, 2013) o la educación (Landers y Callan, 2011).

Dentro de los posibles campos de aplicación de la gamificación, uno sobre los que más se ha investigado es el de la educación. Diversos autores consideran que la gamificación podría utilizarse como mecanismo motivacional que fomente entre los alumnos comportamientos positivos para su formación (Kapp, 2012; Smith-Robbins, 2011). Siguiendo esta línea, y dada la naturaleza eminentemente digital de la gamificación, surge la idea de aplicarla al ámbito del e-learning (Muntean, 2011). Una de las dificultades a la que se enfrenta la formación online son las altas tasas de abandono y la falta de involucración de los alumnos en relación a la formación presencial. Estos problemas se derivan, entre otros, de la ausencia de contacto visual y de comunicación interpersonal entre alumnos y profesor, que limitan la capacidad de este último para ejercer su labor (Dreyfus y Drey, 1986; Flores-Morador, 2013). La motivación y persistencia del propio alumno juegan, por tanto, un papel fundamental en el éxito de una formación e-learning (Paas *et al.*, 2005). La gamificación podría ayudar a mejorar la motivación de los alumnos, y en última instancia, a mejorar sus resultados académicos. Con el objetivo de corroborar esta hipótesis se desarrolló e implantó un módulo de gamificación en un curso universitario impartido a

través de una conocida plataforma de e-learning, exponiéndose aquí los datos, resultados y conclusiones obtenidas a partir de esta experiencia.

Continuando en la línea de trabajo de la motivación en la formación e-learning, una idea complementaria es el uso de redes sociales para involucrar a los alumnos en la formación (Baird y Fisher, 2005). Según esta idea, determinados mecanismos de redes sociales que aumentan la presencia social de los usuarios podrían ser utilizados también en e-learning para conseguir que los alumnos colaboren y trabajen juntos (Cheung *et al.*, 2011). El uso de redes sociales está muy relacionado con la gamificación, ya que muchos videojuegos incorporan redes sociales como parte de su infraestructura para ofrecer a sus jugadores mecánicas y funcionalidades de carácter cooperativo o social. En consecuencia, hay autores que sugieren que ambas ideas podrían utilizarse de forma combinada, creando entornos de aprendizaje motivadores basados en el uso de redes sociales y gamificación (Simões *et al.*, 2013). Después de explorar los efectos de la gamificación en el aprendizaje, continuamos nuestra línea de investigación abordando el estudio de las similitudes y diferencias entre los efectos de las redes sociales en e-learning y los efectos de la gamificación. Para ello desarrollamos, implantamos y evaluamos en contextos muy similares una plataforma de e-learning basada en una red social y otra basada en gamificación. Aquí se presentan los detalles de esta experiencia, sus resultados y conclusiones.

Independientemente de los posibles efectos de la gamificación y redes sociales en el aprendizaje, una de las ventajas de su uso en entornos web como el del e-learning es la posibilidad de obtener gran cantidad de información analizable y explotable sobre la actividad de los alumnos y sobre las relaciones que se establecen entre ellos (Bista *et al.*, 2012; Semenov *et al.*, 2012). Ante este hecho surge la pregunta de si es posible utilizar esta información para predecir los resultados académicos de los alumnos. Una técnica que puede ayudarnos a dar respuesta a esta pregunta es el análisis de redes sociales (SNA). Aplicando SNA es posible estudiar los efectos de las interconexiones entre usuarios de una red social mediante el análisis de su estructura (Martínez *et al.*, 2003; Lee y Bonk, 2016). Nuestro siguiente objetivo es probar este planteamiento a la vez que continuamos profundizando en el estudio del uso de gamificación y redes sociales. Para ello diseñamos e implementamos un entorno de aprendizaje basado en una red social gamificada, y utilizamos técnicas de análisis de redes sociales para encontrar posibles relaciones entre la estructura de la red social generada por los alumnos y su rendimiento académico.

1.1.1. Definición del problema

La formación en modalidad e-learning ofrece ventajas únicas para instituciones y organizaciones dedicadas a la educación, como demuestran tanto el volumen de negocio (Docebo Report, 2014) que genera, como la evolución que está teniendo a nivel global de la que dan ejemplo los MOOC (Masive Online Open Course), cursos online masivos que actualmente imparten universidades en todo el mundo (Pappano, 2012). Sin embargo, el e-learning, aun en la fase de madurez en la que se encuentra, no está exento de problemas importantes como las altas tasas de abandono (Levy, 2007) o las bajas tasas de participación e interacción de los participantes, que pueden traducirse en un escaso impacto de la formación en los alumnos (Welsh *et al.*, 2003). El uso de mecanismos que motiven a los usuarios a participar activamente en la formación online podría ayudar a solventar estos problemas. La gamificación y las redes sociales proporcionan precisamente este tipo

de mecanismos. Por tanto, entender qué efectos y resultados se pueden esperar de su uso, tanto individualmente como de forma combinada, puede ayudar a crear acciones formativas online más atractivas y motivadoras, que en última instancia redunden en un mejor rendimiento académico de los alumnos.

Asimismo, el uso de redes sociales y gamificación en e-learning ofrece otra ventaja: la posibilidad de analizar la actividad de los alumnos para obtener información sobre su nivel participación e interacción. En particular, el análisis de redes sociales en educación permite obtener información útil sobre el progreso del alumno y los resultados académicos que se pueden esperar de él (Cho *et al.*, 2007). Esto puede ser de utilidad para identificar a alumnos en riesgo de abandono y facilitar intervenciones puntuales de los formadores que ayuden a evitarlo (Dawson, 2010). Sin embargo, la mayor parte de estudios existentes en este ámbito se basan en el uso de redes sociales tradicionales que no incorporan mecanismos de gamificación. Surge la cuestión de si mediante el uso de redes sociales gamificadas, que incorporan competición y sistemas de recompensas externos, se pueden crear entornos de aprendizaje significativos para el alumno similares a los generados mediante redes sociales tradicionales. Si esto sucede así, también nos podemos preguntar qué métricas resultan relevantes a la hora de predecir el rendimiento del alumno en base a su actividad en la red social gamificada. Aquí trataremos de dar respuesta a estas preguntas analizando la estructura y los datos de la red social generada durante una formación basada en el uso de una red social gamificada.

La cuestión que se estudia en este trabajo de investigación es, por tanto, determinar los posibles efectos sobre el rendimiento académico del uso de gamificación y redes sociales en e-learning.

1.1.2. Preguntas de investigación

Tras la exposición del problema, a continuación definimos las preguntas de investigación que conducen este estudio:

- PI1: ¿Qué efecto tiene la gamificación sobre el rendimiento académico de los alumnos?
- PI2: ¿Cuales son las diferencias entre el uso de gamificación y el uso de redes sociales en e-learning en relación al rendimiento académico de los alumnos?
- PI3: ¿Qué relación existe entre la actividad de los alumnos en una red social gamificada y su rendimiento académico?

1.2. Revisión del estado del arte

En esta sección introduciremos el estado del arte en las dos áreas de investigación principales de la tesis: gamificación y redes sociales aplicadas al e-learning. Dado que el e-learning es un tema con una ingente cantidad de literatura nos ceñiremos aquí a revisar exclusivamente aquella que esté estrechamente relacionada con las áreas de investigación mencionadas. En cuanto a la literatura sobre gamificación y redes sociales, evitaremos aquella que resulte más genérica, mencionaremos brevemente la que tenga relación con los contextos educativos, y profundizaremos en aquella que trate específicamente sobre su

uso en e-learning, buscando con esto centrar lo máximo posible el discurso sobre el tema de la tesis. Daremos además especial atención a las investigaciones empíricas debido a su más valiosa aportación científica.

1.2.1. Gamificación aplicada al e-learning

La relación entre motivación, videojuegos y educación comenzó a estudiarse en los años 80 con teorías sobre la posibilidad de usar características de los videojuegos en la enseñanza para hacerla más motivadora (Malone, 1980; Bowman, 1982). No es sin embargo hasta la década de los 2000 cuando se realizan un número importante de estudios sobre los videojuegos como herramienta educativa y sus efectos en el aprendizaje y en la motivación de los alumnos (Gee, 2003; Squire, 2003; Facer, 2003). Sin embargo, la gran mayoría de investigaciones empíricas puestas en marcha durante estos años hasta 2012 se limitan al ámbito de los videojuegos educativos y "serious games" (Connolly *et al.*, 2010; Martí-Parreño *et al.*, 2016).

A partir de 2011 comienzan a surgir diversas teorías sobre gamificación aplicada a la educación (Lee *et al.*, 2011). Estas no se basan en el uso de videojuegos para educar, lo que habitualmente resulta demasiado costoso; sino en extrapolar determinadas características de los videojuegos a otros contextos educativos. Dada la naturaleza digital de los videojuegos y la gamificación, el contexto educativo más habitual para la gamificación es el del e-learning. Mediante gamificación sería posible conseguir efectos similares a los de los videojuegos sobre la motivación de los alumnos, pero de una forma más eficiente (Muntean, 2011). Basándose en el Fogg's Behaviour Model, introducido más abajo, Muntean expone diversos mecanismos de gamificación que utilizar en educación como puntos, medallas o rankings. Silva (2010) propone mecanismos similares con un mayor énfasis en la interacción social entre alumnos. Lee y Doh (2012) proponen el concepto de "gameful design", similar al de gamificación, y muestran cómo aplicarlo para diseñar contenidos e-learning que aumenten la motivación intrínseca de los alumnos. Raymer (2011) sugiere distintas ideas para fomentar la participación en sistemas e-learning a través de gamificación. Kapp (2012) ofrece una serie de instrucciones y consejos para el diseño de actividades educativas y su implementación en el aula.

Muchos de estos estudios se basan a su vez en determinadas teorías psicológicas sobre la motivación. La Teoría de la auto-determinación, en inglés Self-determination theory o SDT, es una de las más citadas ya que explica cómo las personas pueden aumentar su motivación intrínseca hacia un cierto comportamiento si al hacerlo satisfacen tres necesidades psicológicas básicas: competencia, autonomía e interrelación. También explica cómo distintas regulaciones externas pueden contribuir positiva o negativamente a aumentar la motivación intrínseca en la medida en la que contribuyan a satisfacer dichas necesidades y sean interiorizadas como propias por el sujeto (Ryan y Deci, 2000). Esta teoría es de gran importancia en el contexto educativo ya que diversos estudios demuestran que la motivación intrínseca es uno de los factores más importantes para mejorar el rendimiento académico de los alumnos (Niemiec y Ryan, 2009). Los mecanismos de motivación propios de la gamificación podrían contribuir a satisfacer las necesidades de competencia, autonomía e interrelación de los usuarios. Deterding (2011) propone para ello el concepto de 'situated motivational affordance', que conecta la SDT con el concepto de 'motivational affordance' de Zhang (2008a), como herramienta para mejorar el proceso de diseño

de sistemas de información y comunicación. Según Deterding los elementos de diseño de un sistema gamificado deben estar orientados a satisfacer las necesidades de competencia, autonomía e interrelación del usuario en cada situación, entendiendo 'situación' tal y como se define en el ámbito de la Interacción Persona-Computador (Dourish, 2004). Adicionalmente a la SDT, algunos autores se basan en otras teorías complementarias sobre la motivación, como el Fogg's Behaviour Model que explica cómo, para que alguien realice un determinado comportamiento, deben darse al mismo tiempo la motivación y habilidad necesarias para hacerlo y un activador que invite a realizarlo (Fogg, 2009); o la taxonomía de Bartle para clasificar jugadores según el tipo de acciones que consideran divertidas y motivadoras dentro del juego (Bartle, 1996); entre otras. En un intento de aunar las diversas teorías sobre educación, diseño y motivación más relevantes en este ámbito, Nicholson y Studies (2012) presenta un marco conceptual para el diseño gamificado de acciones formativas enfocado en las necesidades del usuario.

Sin embargo, las investigaciones sobre gamificación no se limitan al ámbito teórico. A nivel experimental también se desarrollan diversos trabajos que tratan de arrojar luz sobre los efectos reales de la gamificación en la educación. Gåsland (2011) es una de las primeras en hacerlo presentando una plataforma de e-learning gamificada y su implantación en un curso universitario. La plataforma tiene como objetivo que los alumnos puedan plantear y responder preguntas de sus compañeros. El único mecanismo de gamificación incluido son los puntos, que se otorgan como recompensa por participar. Los resultados basados en entrevistas y cuestionarios sugieren que la gamificación es bien aceptada por los alumnos y resulta algo motivadora, pero la propia autora concluye que son necesarias investigaciones más completas que aborden también otros mecanismos de gamificación además de los puntos.

Siguiendo esta línea, Denny (2013), Coetzee *et al.* (2014) y Hew *et al.* (2016) alcanzan conclusiones positivas sobre la gamificación como herramienta para fomentar la participación en plataformas e-learning colaborativas. En estos casos se analizan mecánicas habituales de gamificación como puntos, medallas y rankings. Todos los experimentos incluyen datos de actividad de los alumnos y utilizan grupos de control. Los resultados muestran un incremento significativo del número de contribuciones de los alumnos, especialmente a la hora de responder a preguntas en foros, sin que se observe en ningún caso una disminución de la calidad de sus contribuciones. Sin embargo, no se observan efectos positivos en el planteamiento de nuevas preguntas (Denny, 2013), ni en otros aspectos como las calificaciones, tasa de abandonos o sensación de comunidad (Coetzee *et al.*, 2014).

Otros autores han investigado si estos mecanismos de gamificación sirven para motivar a los alumnos a adoptar otro tipo de prácticas deseables durante su aprendizaje, además de la colaboración en la resolución de preguntas. Landers y Callan (2011) y Hakulinen *et al.* (2013) exponen sus experiencias con gamificación como forma de mejorar los comportamientos relativos a la realización de tareas y test en e-learning. A través de medallas como recompensa por entregar tareas con antelación y con menos errores (Hakulinen *et al.*, 2013), y de posicionamiento en rankings como recompensa por aumentar el tiempo de dedicación a los trabajos (Landers y Callan, 2011), ambos autores demuestran experimentalmente que la gamificación puede utilizarse para modificar positivamente el comportamiento de los alumnos durante su aprendizaje. Sin embargo, los resultados de estos y otros estudios similares sugieren que los efectos positivos en la motivación solo afec-

tarían de forma significativa a un porcentaje reducido de alumnos (Denny, 2013; Coetzee *et al.*, 2014; Landers y Armstrong, 2017), lo que supone una importante limitación al uso de gamificación como herramienta motivacional.

Además de los efectos en la motivación, también se investiga la relación entre el uso de gamificación y el rendimiento académico en comparación con un enfoque e-learning tradicional. Algunos estudios muestran que la gamificación puede tener efecto sobre los resultados académicos de los alumnos, aunque no existe suficiente evidencia al respecto. En el experimento presentado por Landers y Callan (2011), basado en la gamificación mediante retos y rankings de una actividad formativa online consistente en la elaboración de una wiki sobre un cierto tema, se observa que los alumnos que trabajan en la versión gamificada dedican más tiempo a su elaboración y obtienen mejores calificaciones. Por el contrario, otros investigadores no han hallado relación alguna entre gamificación y aumentos del rendimiento académico de los alumnos, aunque sí detecten algunos efectos positivos en otros aspectos (Hakulinen *et al.*, 2013; Attali y Arieli-Attali, 2015). Estos resultados contradictorios dan muestra de que la relación entre uso de gamificación y mejora del rendimiento académico puede depender de diversos aspectos como el diseño de los mecanismos de gamificación, el efecto de las acciones formativas y la forma de evaluación.

En un primer análisis sobre el estado del arte Hamari *et al.* (2014) han estudiado y sintetizado las diversas investigaciones realizadas sobre gamificación y sus beneficios en la motivación, nivel de participación y mejoras de rendimiento en diversos contextos. Este análisis concluye que, aunque la gamificación produce efectos positivos, estos dependen en gran medida del contexto de aplicación y de los propios usuarios. En el contexto de la educación, uno de los más habituales para las investigaciones sobre gamificación, la mayor parte de estudios arrojan resultados positivos, aunque también señalan aspectos negativos que deben ser tenidos en cuenta.

1.2.2. Redes sociales y gamificación social aplicada al e-learning

El uso de redes sociales en e-learning, a diferencia de la gamificación, cuenta con una gran cantidad de estudios, tanto teóricos como prácticos, donde se muestra su efectividad. Las redes sociales permiten a los alumnos establecer conexiones entre ellos que pueden utilizar para comunicarse, colaborar, así como para compartir e intercambiar contenidos. Marijana *et al.* (2011) muestra cómo el uso en el ámbito educativo de redes sociales públicas y generalistas, como Facebook, tiene efectos positivos en el comportamiento y en el rendimiento académico de los estudiantes. Esta relación positiva también se observa al usar redes sociales privadas, ya sean estas generalistas o enfocadas a la educación. Brian (2011) observa una relación positiva entre el uso de la plataforma social generalista Elgg y los logros académicos de sus alumnos. En los estudios de Brady *et al.* (2010) y de Hoffman (2009) con la plataforma social educativa Ning, se observa que esta fomenta la colaboración entre alumnos, y afecta significativamente a su motivación, retención, creatividad y a sus interacciones personales. También se han observado efectos positivos del uso de redes sociales en la calidad del conocimiento (Aviv *et al.*, 2003), la sensación de comunidad (Shen *et al.*, 2008) y la percepción de los alumnos en relación a sus actitudes de colaboración (Martínez *et al.*, 2003). Hay quienes, sin embargo, ponen en duda la validez empírica de una gran parte de estos estudios al estar basados únicamente en entrevistas

y encuestas (Tess, 2013).

Sea como sea, estos resultados positivos muestran que las redes sociales ejercen un efecto positivo en el ámbito del e-learning similar al que se busca con la gamificación, y que quizás, combinando ambos enfoques, podrían lograrse aún mejores resultados. Además, las redes sociales permitirían a su vez introducir elementos de gamificación cooperativos y sociales, en lugar de los elementos competitivos habitualmente utilizados y cuya efectividad está en cuestión. Esto ayudaría a alinear la gamificación con algunas de las teorías psicológicas subyacentes, como la SDT, según la cual uno de los factores más importantes para la motivación de un usuario es la sensación de estar relacionado con el resto (Ryan y Deci, 2000; Zhang, 2008b).

En esta línea, Simões *et al.* (2013) introducen el concepto de gamificación social como la combinación de redes sociales con elementos de gamificación basados en la interacción social, ofreciendo un marco conceptual para facilitar la gamificación social de actividades educativas y poniéndolo en práctica en una plataforma e-learning para niños. Wongso *et al.* (2014) hace algo similar proponiendo un marco conceptual para el diseño de sistemas e-learning gamificados basados en software social propio de la Web 2.0, ya que, según estos autores, el objetivo de la Web 2.0 y de la gamificación es el mismo en esencia, y la combinación de ambos enfoques podría ser positiva. Además, esta idea parece ir amparada por los datos, como los presentados por Hamari y Koivisto (2013) y Hamari y Koivisto (2015), donde se descubre que distintos factores sociales, como las normas subjetivas, el reconocimiento social o la sensación de beneficio mutuo, están directamente relacionadas con el interés y la implicación en el uso de plataformas gamificadas. Además, según el estudio demográfico hecho por Koivisto y Hamari (2014), los factores sociales tendrían aún más importancia entre mujeres y personas de mayor edad, por lo que se trata de un aspecto muy a tener en cuenta en el diseño de experiencias gamificadas en el ámbito educativo.

En los estudios experimentales donde se ha puesto en práctica el enfoque de la gamificación social, los resultados obtenidos parecen corroborar las hipótesis planteadas, siendo positivos por lo general. Mesquita *et al.* (2013) muestra en su estudio la positiva aceptación que tuvo entre los estudiantes el uso de Facebook combinado con algunos mecanismos de gamificación durante un curso de programación. Li *et al.* (2013) presenta el diseño de la plataforma PeerSpace, un entorno de aprendizaje colaborativo basado en una red social privada que incorpora distintas herramientas de la Web 2.0 combinadas con mecanismos de gamificación y pensada para su uso en asignaturas de Ciencias de la Computación. Los resultados del estudio muestran que los estudiantes de la plataforma con mecanismos de gamificación generan mayor número de contribuciones que los que utilizan la misma plataforma sin dichos mecanismos incorporados. Knutas *et al.* (2014) alcanza similares conclusiones con una plataforma de aprendizaje colaborativo gamificada dirigida a fomentar la participación de los alumnos de un curso de introducción a la programación. Los resultados de este estudio muestran mejoras en la colaboración de los estudiantes, la eficiencia en la comunicación y los tiempos de respuesta a las dudas. Según los autores, esta mejora se produjo debido a que los mecanismos de gamificación ayudaron a involucrar a los estudiantes más habilidosos, consiguiendo que resolviesen dudas a sus compañeros y dejando, de esta forma, más tiempo libre a los profesores y asistentes para centrarse en las dudas más complejas y en los alumnos con mayores dificultades. Curiosamente, este y los anteriores estudios mencionados se desarrollan en contextos edu-

cativos relacionados con las Ciencias de la Computación, lo que limita las posibilidades de generalizar las conclusiones obtenidas a otros contextos educativos.

Fuera del contexto de las Ciencias de la Computación podemos encontrar el estudio de Osipov *et al.* (2015), donde se utiliza gamificación en una plataforma web social para el aprendizaje de idiomas con el objetivo de propiciar que los alumnos tengan conversaciones por videoconferencia en un idioma extranjero. En el estudio de Pérez-Pachón *et al.* (2017), realizado en un curso de psicología, se utiliza gamificación para fomentar que los alumnos realicen test opcionales con los que asentar conocimientos, obteniendo medallas y rangos públicos al hacerlo. En ambos casos los resultados son también positivos, pero como apunta Pérez-Pachón *et al.* (2017) en la discusión de su artículo, la validez empírica de su propio estudio, y de la mayoría de los realizados en este ámbito, puede ser puesta en entredicho al carecer de grupos de control o de otras condiciones experimentales adecuadas.

Además de los potenciales beneficios previamente comentados, otra de las ventajas del uso de redes sociales en e-learning es la posibilidad de analizar su estructura para obtener información. El análisis de la estructura de la red social, proceso conocido como *Social Network Analysis* o SNA, nos permite estudiar la relación entre el comportamiento de los estudiantes y la posición que ocupan dentro de la red social. Existen estudios que muestran la influencia de la actividad del usuario en la red social sobre su aprendizaje social y académico Tian *et al.* (2011) y también se han encontrado relaciones entre el nivel de uso de la red social y la percepción de aprendizaje Brian (2011). De forma más concreta, las investigaciones realizadas por Cho *et al.* (2007), Maglajlic y Gütl (2012) y Putnik *et al.* (2016) muestran que determinadas propiedades de los nodos de una red social relativas a la centralidad, tienen una influencia significativa en el rendimiento académico de los estudiantes. Las propiedades de la red social en su conjunto también tienen efecto en el aprendizaje de los alumnos. En el estudio dirigido por Paredes y Chung (2012) se observa cómo la densidad y la comunicación inter-grupal dentro de la red social afectan positivamente al aprendizaje. En la misma línea, según Gaggioli *et al.* (2015), la densidad y descentralización de la red social afecta a la creatividad de los alumnos. Dentro de este campo de estudio, no se han encontrado artículos específicos de análisis de redes sociales gamificadas.

1.3. Objetivo de investigación

A continuación se enumeran los objetivos de esta tesis:

Analizar los efectos del uso de gamificación y redes sociales en la formación online

1.- Estudiar los efectos de la gamificación en el ámbito del e-learning

2.- Comparar los efectos de la gamificación y las redes sociales respecto a la formación e-learning tradicional

1.4. Contribución

Como fruto de un exhaustivo análisis del estado del arte sobre el uso de gamificación y redes sociales en e-learning descubrimos numerosos artículos teóricos sobre la materia, pero un escaso número de publicaciones con resultados experimentales. En consecuencia, procedimos a diseñar y elaborar distintos experimentos con los que evaluar algunos de los planteamientos teóricos propuestos por otros autores. En esta tesis se presentan los resultados de nuestra investigación como un compendio de artículos de impacto: su contribución está basada en tres artículos publicados en revistas de impacto indexadas en el Journal Citation Report.

Impacto del artículo 1

Título	Domínguez, A., Saenz-De-Navarrete, J., De-Marcos, L., Fernández-Sanz, L., Pagés, C., & Martínez-Herráiz, J. J. (2013). Gamifying learning experiences: Practical implications and outcomes. Computers and Education, 63, 380–392. http://doi.org/10.1016/j.compedu.2012.12.020
Resumen	La gamificación es el uso de mecánicas de juego y otros elementos del diseño de juegos en contextos no jugables. Esta idea ha sido utilizada con éxito en distintos negocios basados en plataformas web, como forma de conseguir dirigir y aumentar las acciones que realizan los usuarios según los objetivos de negocio. Ante este hecho, surge la pregunta de qué efectos puede tener la gamificación en el aprendizaje al aplicarla en el contexto del e-learning. En un intento por aportar respuestas a esta pregunta, en este artículo mostramos los resultados de la aplicación de un plugin de gamificación diseñado e implementado dentro de una conocida plataforma de e-learning. Los resultados sugieren que la gamificación puede tener efectos tanto positivos como negativos en distintos aspectos del aprendizaje y su efectividad puede variar mucho entre alumnos.
Impacto	Este artículo ha sido publicado en una de las principales revistas internacionales de investigación en el campo de las ciencias de la computación y la educación, Computers & Education, publicada por Pergamon-Elsevier Science LTD en Oxford, Reino Unido. Computers & Education tuvo un factor de impacto de 2,630 y ocupó la posición 15 de 102 (Q1) en la categoría "Computer Science, Interdisciplinary Applications" del Science Index del Journal Citation Reports 2013. Según el SJR SCImago Journal & Country Rank 2013 esta revista tuvo un SJR de 2.558, un H-Index de 77, y ocupó la posición 9 de 235 (Q1) en la categoría "Computer Science (miscellaneous)" y la posición 20 de 1305 (Q1) en la categoría "Education". El artículo ha conseguido 188 citas desde su publicación según Web of Science, 313 citas según Scopus y 677 citas según Google Scholar. Este hecho le ha permitido alcanzar el estatus de "Highly Cited Paper" en Web of Science, lo que indica que está dentro del 1 % de artículos más citados dentro de su campo académico y su año. También se ha destacado como el tercer artículo más citado en la revista Computers & Education de entre los publicados en los 5 últimos años, a partir de 2012, y en la actualidad figura en la lista de los 25 artículos más descargados de la revista durante los últimos 3 meses. Estos datos están actualizados a fecha de 25 de octubre de 2017.

Tabla 1.1: Artículo 1.

Impacto del artículo 2

Título	De-Marcos, L., Domínguez, A., Saenz-De-Navarrete, J., & Pagés, C. (2014). An empirical study comparing gamification and social networking on e-learning. Computers and Education, 75, 82–91. http://doi.org/10.1016/j.compedu.2014.01.012
Resumen	Las redes sociales y la gamificación son dos mecanismos que pueden utilizarse en el e-learning para conseguir experiencias más atractivas y motivadoras, aunque sus efectos a nivel académico no están claros. Este artículo presenta los resultados del uso de redes sociales y gamificación en e-learning, comparando los efectos de estos instrumentos en los resultados académicos, la participación y la actitud de los alumnos. Al igual que en experimentos anteriores, se confirma que la gamificación tiene efectos positivos en actividades de tipo práctico, aspecto compartido con las redes sociales. Sin embargo, el enfoque del e-learning tradicional parece resultar más efectivo para el aprendizaje teórico. El experimento sigue poniendo a prueba determinadas hipótesis que asocian la gamificación y las redes sociales con mayores tasas de participación de los alumnos.
Impacto	Al igual que el artículo anterior, este artículo fue publicado en Computers & Education, revista enfocada a mejorar el conocimiento de las formas en las que la tecnología digital puede mejorar la educación, nacida en 1976 y publicada actualmente por Pergamon-Elsevier Science LTD. Computers & Education tuvo un factor de impacto de 2,566 y ocupó la posición 16 de 102 (Q1) en la categoría "Computer Science, Interdisciplinary Applications" del Science Index del Journal Citation Reports 2014. Según el SJR SCImago Journal & Country Rank 2014 esta revista tuvo un SJR de 2.578 y un H-Index de 93, ocupando la posición 8 de 234 (Q1) en la categoría "Computer Science (miscellaneous)" y la posición 15 de 914 (Q1) en la categoría "Education". El artículo ha conseguido 62 citas desde su publicación según Web of Science, 83 citas según Scopus y 184 citas según Google Scholar. Al igual que con el anterior artículo, el número de citas conseguido le ha permitido alcanzar el estatus de "Highly Cited Paper" según Web of Science. También ocupó la posición 16 en el ranking de los 25 artículos más descargados de la revista Computers & Education en 2014. Estos datos están actualizados a fecha de 25 de octubre de 2017.

Tabla 1.2: Artículo 2.

Impacto del artículo 3

Título	De-Marcos, L., Garciá-López, E., Garciá-Cabot, A., Medina-Merodio, J. A., Domínguez, A., Martínez-Herraíz, J. J., & Diez-Folledo, T. (2016). Social network analysis of a gamified e-learning course: Small-world phenomenon and network metrics as predictors of academic performance. Computers in Human Behavior, 60, 312–321. http://doi.org/10.1016/j.chb.2016.02.052
Resumen	Además de los potenciales efectos de la gamificación y redes sociales sobre los alumnos en la formación e-learning, estas herramientas pueden tener otros usos, como el de obtener información relevante sobre los alumnos en base a los datos capturados sobre su actividad. Ante este planteamiento surge la cuestión de qué modelos predictivos se podrían elaborar en este sentido. Este artículo trata de aportar respuestas elaborando un modelo predictivo del rendimiento académico a partir de la estructura de la red social generada durante un curso e-learning y su análisis mediante la técnica SNA (social network analysis). Los distintos métodos utilizados para analizar la estructura de la red social sugieren distintas métricas clave con influencia en el rendimiento académico, todas ellas relativas a la centralidad, pero muestran también ciertas limitaciones en la representatividad del modelo, dejando la puerta abierta a la búsqueda de modelos más representativos mediante métodos de análisis alternativos.
Impacto	Computers in Human Behavior es una revista internacional publicada por Pergamon-Elsevier Science LTD en Oxford, Reino Unido, dedicada al estudio del uso de las computadores desde un punto de vista psicológico, así como a la interacción persona-computador. Computers in Human Behavior tuvo un factor de impacto de 3.435, ocupando la posición 15 de 128 (Q1) en la categoría "Psychology, Multidisciplinary" y la posición 10 de 84 (Q1) en la categoría "Psychology, Experimental" del Social Science Index del Journal Citation Reports 2016. Según el SJR SCImago Journal & Country Rank 2016 esta revista tuvo un SJR de 1,599 y un H-Index de 111, ocupando las posiciones 3 de 276 (Q1) en la categoría "Human-Computer Interaction", 44 de 444 (Q1) en la categoría "Arts and Humanities (miscellaneous)" y 21 de 231 (Q1) en la categoría "Psychology (miscellaneous)". El artículo ha conseguido 3 citas desde su publicación según Web of Science, 8 citas según Scopus y 11 citas según Google Scholar. Estos datos están actualizados a fecha de 25 de octubre de 2017.

Tabla 1.3: Artículo 3.

1.4.1. Resumen de la contribución

Como muestra el impacto de los artículos detallado en las tablas anteriores, esta tesis:

Contribuye a un mayor conocimiento y compresión sobre la forma en que gamificación y redes sociales, dos técnicas con un fuerte aspecto motivacional, pueden afectar al rendimiento académico al aplicarse al contexto del e-learning.

Las tres publicaciones contribuyen a dar respuesta de forma empírica a las distintas hipótesis planteadas por diversos autores en el ámbito del uso de gamificación y redes sociales en e-learning. Además, cada uno de los artículos analiza esta cuestión desde una perspectiva distinta, por un lado tratando de medir el efecto de cada una de estas técnicas en el rendimiento académico en comparación con un enfoque e-learning tradicional, y por otro buscando las métricas más relevantes que podrían contribuir a dicho efecto.

La siguiente tabla muestra de qué forma se relaciona cada artículo con las preguntas de investigación planteadas:

	Título del artículo	PI1: ¿Qué efecto tiene la gamificación sobre el rendimiento académico de los alumnos?	PI2: ¿Cuales son las diferencias entre el uso de gamificación y el uso de redes sociales en e-learning en relación al rendimiento académico de los alumnos?	PI3: ¿Qué relación existe entre la actividad de los alumnos en una red social gamificada y su rendimiento académico?
1	Gamifying learning experiences: Practical implications and outcomes.	**Respondida**	**Aporta información parcial**	
2	An empirical study comparing gamification and social networking on e-learning.	**Aporta información adicional**	**Respondida**	
3	Social network analysis of a gamified e-learning course: Small-world phenomenon and network metrics as predictors of academic performance.			**Respondida**

Tabla 1.4: Relación entre artículos y preguntas de investigación.

1.5. Estructura de la tesis

La tesis sigue la siguiente estructura: Tras este capítulo de introducción donde, además del estado del arte, se puede encontrar un resumen del impacto de las publicaciones y las relaciones entre ellas, seguidamente se presentan los tres artículos en orden cronológico de publicación, para posteriormente abordar la discusión de los resultados, las conclusiones y las líneas de trabajo futuro.

- El capítulo 2 presenta el primer artículo de la tesis, relativo al uso de la gamificación en el ámbito del e-learning y su efecto sobre el rendimiento académico. Este artículo es el punto de partida de la tesis y sirve como primera aproximación a la investigación desarrollada.
- El capítulo 3 presenta el segundo artículo de la tesis, donde se continúa con la línea abierta en el primer artículo, introduciendo ahora el uso de redes sociales en e-learning y comparándolo con un enfoque gamificado y otro tradicional. Este artículo vertebra la investigación y sirve para conectar con el siguiente, más centrado en aspectos específicos de las redes sociales.
- El capítulo 4 presenta el tercer artículo de la tesis, donde se aborda cómo podrían utilizarse los datos de una red social gamificada en e-learning para obtener, mediante un proceso de análisis de redes sociales, información de interés sobre el rendimiento académico de los alumnos. Este es el último artículo presentado en la tesis.
- En el capítulo 5 se presenta una discusión de los resultados globales de los tres artículos de la tesis, mientras que el capítulo 6 se resumen las conclusiones y las posibles líneas de trabajo futuro.
- En relación a la bibliografía, cada uno de los artículos de la tesis incluye un apartado final donde se muestran sus referencias, mientras que las referencias utilizadas en las restantes secciones de la tesis se enumeran al final de la misma, en un listado separado.

Capítulo 2

Estudio de los efectos de la gamificación en el aprendizaje

2.1. Contribución del artículo 1

La formación universitaria en modalidad semipresencial o a distancia se encuentra con el reto de conseguir motivar a los alumnos para que aprovechen los recursos online que se ponen a su disposición. Uno de los recursos más importantes son las actividades, que invitan a los alumnos a poner en práctica los conocimientos teóricos que van adquiriendo durante su formación con el objetivo de asentar conocimientos y que se encuentren mejor preparados para las pruebas de evaluación de la asignatura. Existen diversos factores bajo el control de las instituciones educativas que pueden afectar a la motivación de los alumnos para realizar dichas actividades. El profesor es uno de los más importantes, aunque en la modalidad de formación semipresencial o a distancia sus posibilidades pueden estar limitadas debido a la escasez de contacto directo con sus alumnos. Otros factores de motivación son el diseño de las propias actividades y las características de la plataforma e-learning bajo la cual estas les son ofrecidas a los alumnos. Debido a las limitaciones del profesor en este tipo de formación, resulta interesante encontrar formas de motivar a los alumnos a través de las propias actividades y de la plataforma e-learning.

En este contexto es donde entra en juego la gamificación como instrumento de motivación. Los sistemas gamificados online utilizan técnicas de diseño y mecanismos de motivación propios de los videojuegos, tales como retos incrementales, feedback inmediato y recompensas. Con estos elementos se busca conseguir cambios en el comportamiento de los usuarios orientados a un mejor aprovechamiento de las funciones del sistema y a un mayor nivel de interacción e implicación. Muchos de estos mecanismos usualmente están automatizados y requieren de una mínima o nula intervención humana. En consecuencia, la gamificación parece idónea para ser utilizada en el contexto planteado. Por un lado, ofrece técnicas de diseño que podrían ayudar a hacer las actividades más atractivas. Por otro, ofrece mecanismos que podrían aplicarse a las plataformas e-learning para hacerlas más motivadoras.

En este capítulo presentamos y estudiamos los resultados de una primera aproximación a esta idea a través de una plataforma e-learning gamificada, en el contexto de una asignatura universitaria semipresencial, cuyo objetivo es motivar a los alumnos a realizar prácticas optativas y a enviarlas al profesor para su corrección.

2.2. Artículo 1

A continuación se incluye el artículo 1, “Gamifying learning experiences: Practical implications and outcome”, en su versión pre-print.

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Gamifying learning experiences: Practical implications and outcomes

Abstract: Gamification is the use of game design elements and game mechanics in non-game contexts. This idea has been used successfully in many web based businesses to increase user engagement. Some researchers suggest that it could also be used in web based education as a tool to increase student motivation and engagement. In an attempt to verify those theories, we have designed and built a gamification plugin for a well-known e-learning platform. We have made an experiment using this plugin in a university course, collecting quantitative and qualitative data in the process. Our findings suggest that some common beliefs about the benefits obtained when using games in education can be challenged. Students who completed the gamified experience get better scores in practical assignments and in overall score, but our findings also suggest that these students performed poorly on written assignments and participated less on class activities, although their initial motivation was higher.

Keywords: gamification, games-based learning, computer game, game mechanic, motivation, engagement, e-learning

1. INTRODUCTION

Since the 1970s and 80s, video games have been increasing their popularity over time as a form of entertainment. Firstly oriented towards a male audience, the video game industry has made big efforts to expand its market and reach more kinds of people, especially women and families. But it was not until the most recent years that the industry achieved this objective, with two clear examples, the Wii console system, and the Facebook social games, both with millions of users around the world. Currently, video games are the most powerful entertainment industry in economic terms[1], and are also considered an incipient form of art[2].

Education researchers have viewed this kind of entertainment with great interest. Video games are interactive activities that continually provide challenges and goals to the players, thus involving them into an active learning process to master the game mechanics (Koster, 2005). At the same time, video games provide a fictional context in the form of narrative, graphics and music, which if used appropriately, can encourage the interest of players on non-gaming topics, like for example, history (Watson, Mong & Harris, 2011). Due to this potential, a lot of work has been done trying to unveil how video games could be used successfully with educational purposes. In the 1980s

[1] Factbox: A look at the $65 billion video games industry. June 6, 2011. Reuters. http://uk.reuters.com/article/2011/06/06/us-videogames-factbox-idUKTRE75552I20110606
[2] Art-s in Media. http://arts.gov/grants/apply/AIM-presentation.html

Malone (Malone, 1980) and Bowman (Bowman, 1982) theorized about what makes computer games so appealing to players, and how those aspects could be applied in education to improve student motivation and engagement. Over time researchers conducted many theoretical and empirical studies on this subject. These studies have unveiled many potential advantages of videogames in education like immediate feedback, information on demand, productive learning, motivating cycles of expertise, self-regulated learning or team collaboration (Rosas, Nussbaum & Cumsille, 2003; Gee, 2003); but also some issues related to educative content, learning transfer, learning assessment, teacher implication and technological infrastructure (Squire, 2002, 2003; Facer, 2003). Recently Connolly, Boyle, MacArthur, Hainey & Boyle (2012) presented a systematic literature review on games-based learning and serious gaming focusing on positive outcomes. They also stress the necessity of more rigorous evidence of games' effectiveness and real impact.

Due to mentioned issues, some researchers do not focus on using videogames to educate, but on exporting good aspects of video games to non-gaming educative contexts. This concept, which is not exclusive of education, is commonly called 'gamification'. Some researchers generically defined it as the use of game design elements and game mechanics in non-game contexts (Deterding, Dixon & Khaled, 2011), although this broad definition has been further refined to reflect the most common objective of gamification: increase user experience and engagement with a system. Another relevant fact is that, like videogames, gamification is still based on technology, and it's almost always applied on desktop, web or smartphone applications. Attending to these facts, it could be more narrowly defined as incorporating game elements into a non-gaming software application to increase user experience and engagement. This last definition is the one we will use for the rest of the paper.

Gamification has been incorporated with commercial success into platforms[3], especially social ones, as a way to create narrow relationships between the platform and the users, and to drive viral behaviors on them to increase platform popularity. This success has made some researchers theorize that it could also be used in education as a tool to increase student engagement and to drive desirable learning behaviors on them (Lee & Hammer, 2011). Attending to its technological nature, one of the fields where gamification may have a greater impact is online learning. Its potential benefits

[3] A notable example is Badgeville. http://www.badgeville.com/

may address well-known issues as, for example, the lack of student motivation due to the limited capacity of interaction with teacher and classmates (Liaw, 2008). In addition, the monitoring and communication infrastructure of e-learning platforms provides the necessary tools to incorporate different gamification mechanisms and to measure their usage by students.

This paper will make a contribution to the empirical evidence in the field by designing, implementing and evaluating a gamified learning experience in tertiary education. Our research tries to bridge the gap between theory and practice and study the design and consequences of applying gamification in a real educational setting. The rest of the paper is structured as follows: Section 2 presents previous research of gamification in education. Section 3 presents a theoretical analysis of videogames and motivation. Section 4 presents the system's design and section 5 briefly outlines the technological architecture. Section 6 presents the experimental design. Section 7 presents quantitative and qualitative results and discussion on those results. Finally, conclusions and future research lines are outlined in section 8.

2. PREVIOUS RESEARCH

While some researchers are already working on it, currently there is still little work on this subject. Muntean made a theoretical analysis of gamification as a tool to increase engagement in e-learning platforms (Muntean, 2011). Based on Fogg's Behaviour Model, the author states that gamification mechanics can be used to motivate and trigger desired behaviors on students. Although he provides a list of gamification elements explaining how they could be included in an e-learning course, there is no empirical research so, in our opinion, more work will be required to give an implementation and obtain evidence about its effect on students.

Silva proposes another list of gamification elements, focusing specifically on social game mechanisms, that could be included in e-learning courses to increase student motivation by means of new interaction mechanisms with classmates (Silva, 2010). Customization, community interaction or leaderboards are some of the proposed mechanisms, but the author provides little guidance of how to apply them on education, so more work is needed in this area.

Recently Simões, Díaz & Fernández (2012) presented a social gamification framework for schoooools.com, a social learning environment, which "aims to assist educators and

schools with a set of powerful and engaging educational tools to improve students' motivation and learning outcomes" (p. 3). This framework enables teachers to deliver contents fitted to learning contexts and students' profiles by choosing the appropriate social gamification tools, based on social games' mechanics and dynamics. These authors also present a scenario describing how a specific mechanic can be integrated using a point-based reward system, thus demonstrating the extensibility of the framework, but there is no empirical evidence about the effectiveness of this approach.

One of the few empirical researches on this subject is the master's thesis "Game mechanic based e-learning" (Gaasland, 2011). In her work, Gaasland presents a detailed experiment in which she developed a web platform for a gamified e-learning experience and evaluated it with a university class. The platform served as a collaborative database where students could create and answer questions, using it as an alternative way to study and revise topics. Apart from the collaborative aspect, the only gamification mechanism is Experience Points, a classic videogame mechanic used to keep track of progression. Results suggest that the platform is somewhat motivating, but that much more research is needed to test other gamification mechanisms and their combinations.

Our objective is to continue working on the line of the previous papers from an empirical point of view, studying also the motivational impact of different gamification mechanisms. For that, we have created an e-learning gamification system that includes a limited set of those mechanisms, and we have tested it on a university course, obtaining qualitative and quantitative data from the students. This contribution will lead to a better understanding of the effects of gamification on e-learning.

3. VIDEOGAMES AND MOTIVATION

To create a gamification system that increases student motivation it is necessary to focus on the fundamental elements that make videogames appealing to their players. According to Lee & Hammer (2011), games are motivating because of their impact on the cognitive, emotional and social areas of players; and so, gamification in education should also focus on those three areas.

In the cognitive area, a game provides a complex system of rules along with series of tasks that guide players through a process to master those rules. These tasks are designed as cycles of expertise (Gee, 2003). A cycle consists of a series of short-term

tasks which players repeatedly try to complete in a try and fail process until the necessary skill level is acquired. When the player is involved in this learning process, games try to assure that players always know what to do next, and that they have the necessary knowledge to do it. To make the learning process customizable, task sequences are usually non-linear, and players have a certain degree of freedom to choose which tasks to accomplish depending on skill and personal preferences.

The impact on the emotional area works mainly around the concept of success and failure. On one hand, when players complete tasks they are expected to have positive emotions by their mere fact of overcoming difficulties. Games try to assure and increase those feelings with reward systems that give immediate recognition to players' success, awarding them with points, trophies or items on task completion. On the other hand, when players fail, they are expected to feel anxiety. While some degree of anxiety is acceptable, it is not desirable that it transforms into frustration. To avoid that, sequences of tasks are carefully designed to fit players' skills at any level, and include low penalties on failure to promote experimentation and task repetition. If the difficulty of tasks is correctly balanced, it can drive the players to a flow state which is highly motivating (Csikszentmihalyi, 2008).

When multiple players interact through the game, these interactions have impact on players' social area. Videogames offer a wide range of multiplayer interaction mechanisms which are integrated in the rules of the system. These mechanisms make it possible for players to cooperate helping each other towards a common goal, to compete trying to impair other players or to perform better than them, or just to interact socially by talking, flirting, trading or gifting for example. All these kinds of interaction let players build different in-game identities taking meaningful roles and obtaining recognition from other players (Lee & Hoadley, 2007).

All these three areas (cognitive, emotional and social) seem to be the base for player motivation, but their limits are blurry and game mechanics usually cover more than one at the same time. For example, many items that are awarded to players on success are just keys to new cycles of expertise that increase game complexity and difficulty, impacting both emotional and cognitive areas. Social area is always mixed with cognitive area, when a task must be solved by means of player cooperation or competition; or with emotional area, when rewards systems have an impact on players' social status.

The main objective behind gamification in education is to apply some of these ideas when designing educative initiatives and their contents in an attempt to make them more motivating. The fact that technology is necessary to implement most of the exposed mechanisms makes e-learning platforms an ideal environment for experimentation.

4. SYSTEM DESIGN

According to elements exposed in the previous section, we have designed a gamified educative experience in which some of those elements are adapted and applied on an e-learning platform used as a tool in a university course. The course "Qualification for users of ICT" is a transversal course in which students of different grades learn how to effectively use common ICT tools. The course is aimed at promoting basic ICT competence at user level for students. It is inspired in the well-known ECDL (European Computer Driving License)[4], a de-facto vendor-independent standard in Europe for ICT literacy, with millions of certified people. Syllabus includes modules on general ICT knowledge, basic use of operating system, word processor, spreadsheet, presentation software, database and communications skills with web browsers and email. The course has optional exercises designed to improve the skills of students so that they perform better on final exams. These exercises are usually downloadable from a Blackboard e-learning platform as PDFs. Instead of providing them as downloadable text files, we have created a Blackboard plugin which provides the same exercises in a gamified way. The main objective of this plugin is to increase student motivation towards completing optional exercises through the use of rewards and competition mechanisms. In the following sections we describe the design of this plugin.

4.1. Cognitive area

The first step was the design of the cognitive area of the experience. In this case, the system of rules in which students must obtain skills is provided by the ICT tools used in the course, and the tasks that guide the player in the tool mastery process are the optional exercises. Due to our research objectives, we decided that the gamification impact on this aspect should be limited in order to keep gamified tasks as similar as possible to traditional optional exercises. Our solution was to create a hierarchical tree following the course topics and optional exercises structure (Fig. 1). First level of the tree matches subject's list of topics; second level matches optional exercises for each topic, called 'challenges'; third level matches specific tasks in each challenge, called

[4] http://www.ecdl.com/

'trophies' or challenge activities; and fourth level matches specific steps in each stage that provide students with a detailed description of the work they have to do in order to obtain the trophy. Students can freely access any topic and its challenges once it has been introduced in lectures. Trophies in a challenge are designed to be increasing in difficulty and based on the previous ones, so they are sequentially unlocked as the student completes them. In order to make this hierarchy clear for the students, we included two challenges per topic – intermediate and advance – and at most four trophies per challenge – copper, silver, gold and platinum, each element with an appropriate visual representation (Fig. 2). Although these tasks are presented in videogame-like fashion, they are exactly the same as their traditional counterparts presented in PDF format.

- …
- Module 2 – Word Processors
  - Challenge 1 – Word Intermediate
    - Level 1 – Titles and Styles
    - Level 2 – Bullets
      1. Start a bulleted list
      2. Change the style of the newly created bulleted list
      3. Justify all the text except the main title
      4. …
    - Level 3 – Table of contents and headings
  - Challenge 2 – Word Advanced
    - …
- Module 3 – Spreadsheets
  - …

Fig. 1. Sample of hierarchical tree for course 'Qualification for users of ICT'.

Fig. 2. Screen capture showing a challenge and its four trophies. Copper, silver and gold trophies are completed, while platinum trophy is unlocked but not yet completed (in Spanish).

Another important element of this area was task evaluation. Traditional exercises were not evaluated at all, but in order to be able to reward task completion, we required an evaluation mechanism. An ideal mechanism would be integrated in the e-learning platform, making it possible for student to auto-evaluate their tasks. Nevertheless, this is not always possible, as in our case, where exercises had to be done using external software. The solution we came through was to use screenshots as evaluation mechanism, as we thought that it was simple for students to capture and upload screenshots of their work while they were completing a task, and that those screenshots could provide enough information for teachers to evaluate if the task was correctly completed or not. The problem with this solution is that if students needed to wait for teacher to evaluate their work, it would be impossible to give immediate feedback on task completion in the form of a reward (more about rewards in the following section). To avoid this, we decided to immediately accept any uploaded screenshot as correct, leaving the evaluation as a verification mechanism to see if students were being honest and if their work was correctly done. In future initiatives we may consider computer-based testing (Santos, et. al., 2012; Santos, et. al., 2011) to overcome these problems.

4.2. Emotional area

Next step was to design how to impact on the emotional area of students. Our proposal was to include a virtual reward system that could create positive emotions on task completion, thus motivating students to complete more tasks. According to Wang and Sun's work on game reward systems, there are eight forms of rewards: score systems, experience points, items, resources, achievements, instant feedback messages, plot animations, and game content (Wang & Sun, 2011). Most of these rewards cannot be easily incorporated in gamification systems. The lack of virtual worlds, avatars and stories make it difficult to include experience points, items, resources, plot animations or unlockable game content. Instant feedback messages seem to be great to create positive emotions, but such a reward system is not feasible because it would require to be integrated within the external software used by students to complete tasks. After examining the remaining reward systems, points and achievements, we decided that achievements were the most appropriate form of reward for us. According to Wang's definition, "achievement systems consist of titles that are bound to player accounts; users collect them by fulfilling clearly stated conditions" (p. 4). In our gamified experience students will have to complete tasks in order to obtain achievements.

Although a score system may also fit in our design, we left it out to keep design as simple as possible.

Achievements may generate a wide range of positive emotions. One possible emotion is related to the fact of being immediately rewarded on task completion, as students will feel that they are performing well. To increase this feeling, we decided to represent some special achievements as medals, a typical representation of excellence (Fig. 3). Another one is related to the fact of achievement being collectables. Non-completed achievements are shown to the player as a list of tasks to perform, with an empty space for the corresponding medal. Players motivated by collectables will be tempted to continue working in order to get all medals. Finally, some achievements have been designed as hidden; they are awarded by surprise when some special conditions are met. In addition to being surprised with an award, these achievements may also serve to promote exploration of system features in order to discover the secret medals.

Fig. 3. Sample of some special achievements represented as medals.

4.3. Social area

The final design step is related to the social area of the system. As previously exposed, there are different ways of student: interaction, cooperative, competitive and social. Due to the individual design of course exercises, cooperative interaction didn't have sense in our system. Between the remaining two, we decided to include only competitive mechanisms to be able to study their effect over students in isolation; thus leaving social mechanisms for future works. The most basic mechanic of competition in many videogames is a leaderboard or ranking, so we opted to include this mechanic in our system. Usually leaderboards are score based, but due to the lack of a score system in our design we used achievements instead, ranking players by the number of achievements they own (Fig. 4). This leaderboard let students compete to obtain higher ranking by completing more exercises and by participating in the overall experience.

This could be a source of motivation for competitive students. Additionally two other competition mechanisms are provided. One of them lets a player view a comparison between his achievement list and the achievement list of any other classmate. Comparison view could drive more direct competition between two specific players who are trying to beat each other. The other included mechanism shows a list with all the achievements in the platform, along with the percentage of total users who own it. This lets players challenge themselves to obtain the most exclusive achievements.

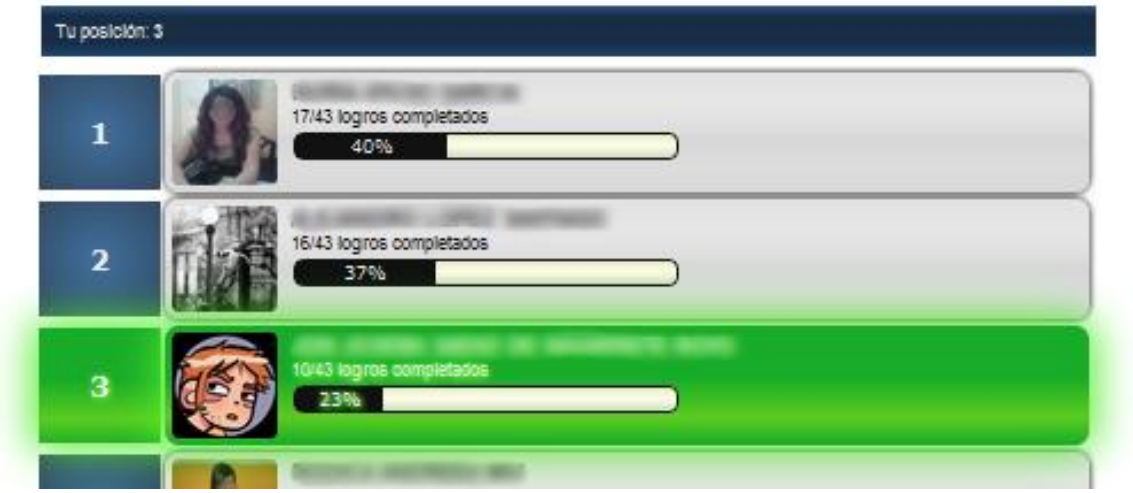

Fig. 4. Leaderboard sample, each row shows player's photo, ladder position, number of achievements, and percentage of total achievements.

5. SYSTEM ARCHITECTURE

In this section we will briefly describe system architecture. While "Qualification for users of ICT" course used Blackboard 8 (BB8) as e-learning platform for online content, custom plugin support was made available only since Blackboard 9 (BB9) version. We solved this problem by implementing a gamification plugin for the BB9 platform and deploying it on a parallel course to the BB8 one. Students could use the same login credentials in BB8 and in BB9 platforms; traditional content was available in the former and gamified content in the latter.

Several technologies were used to implement the system (Fig. 5). Blackboard 9 plugins are JSP web applications that can access student data, and in consequence, don't require user authentication. Although the e-learning platform database could supposedly be used to store plugin data, several problems were found at developing time, mainly related with the amount of documentation available, so we decided to explore alternative solutions. We decided to create a cloud-based web service in Microsoft Azure platform linked to a

SQL Azure database. This service was consumed from client-side using AJAX. It was designed using the RESTful principles, and programmed in C# using Windows Communication Foundation. Lastly, Amazon EC3 cloud based persistent storage services were used to store screenshots and user avatars.

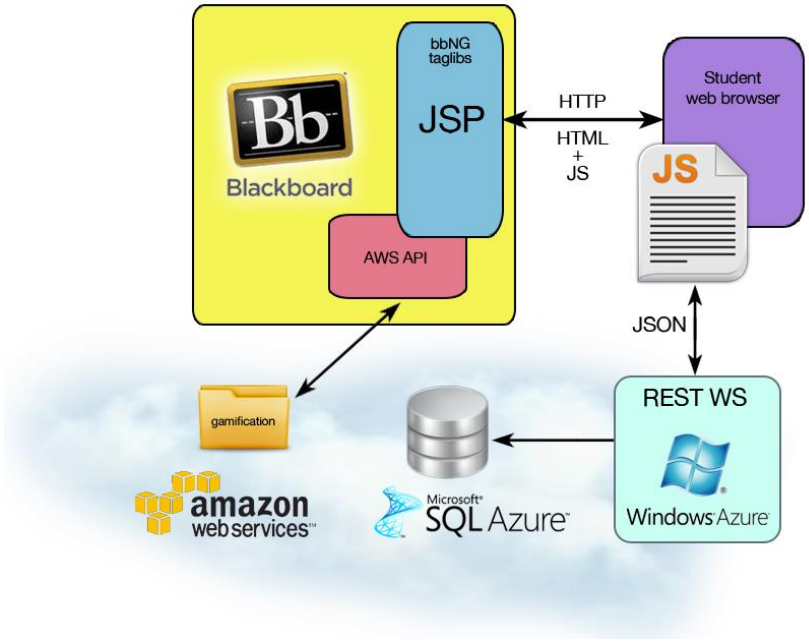

Fig. 5. System architecture diagram.

6. EXPERIMENTAL DESIGN

In order to assess the effectiveness of the gamified approach and to evaluate the attitude of students we designed an experiment for two different groups of the course "Qualification for users of ICT" (6 ECTS, 150-180 hours of student work). This course is based on the ECDL certification syllabus and has the following modules:

1. Introduction to the computer, the operating system, networks and communication.
2. Word processor
3. Spreadsheets
4. Presentation software
5. Databases

The final score of the course is computed based on the following evaluation items:

- Initial activity (5%).
- Midterm assignment (30%)
- Final assignment (30%)

- Final examination (30%)
- Participation (5%)

The *initial activity* (week 1) is designed to introduce the course to the students, to get them used to the course stuff and class dynamics, including the e-learning platform, and also to collect basic information about them. Students are asked to complete their personal profile, fill two surveys about their knowledge and their usage of ICT, and also to complete a short interactive test to assess their initial knowledge about modules 2 to 6 (word processor, spreadsheets, presentation software and databases). Questions in this test cover just basic initial topics about each module but they turn out to be interesting for two reasons: firstly, students get a first glimpse of the overall contents and skills required to pass the course, and secondly, initial scores for each module are collected given useful information to both student and teacher. Teachers consider that this score is an indicator of the initial motivation of the student instead of being a precise score of her initial knowledge. Activities are designed to motivate the student to participate and complete the course. In the *midterm assignment* (week 10) students have to hand in two exercises which correspond to modules 2 (word processor) and 3 (spreadsheets). On the *final assignment* (week 14) students submit their exercises of modules 4 (presentation software) and 5 (databases). The *final examination* (week 15) is a written test comprised of multiple choice as well as open-ended questions. Finally students can get up to a 5% of the final score based on their *participation* on the activities that take place in classroom as well as on the virtual classroom (e-learning platform). This score is computed semi-automatically taking the number of interactions on the e-learning platform (posts in the forum, elements opened, activities completed, messages read, etc… and also challenges, trophies, achievements, leaderboard, etc…) and a subjective assessment of the lecturer based on the student attendance and participation in classroom. With this system of evaluation it is possible to have 7 scores per student (initial activity, word processor, spreadsheet, presentation software, databases, final examination and participation) as well as the final score. All scores can be used to compare the performance of different groups. None of the evaluation instruments was gamified.

During the spring semester the course “Qualification for users of ICT” is given to two distinct groups. As it is a transversal course, it is offered to a wide range of students majoring different specialties. The *control group* consist of 1st and 2nd year university students (freshmen and sophomores) majoring construction engineering, nursing, tourism, infant education, primary education or business administration and

management. 80 students enrolled initially and 73 completed at least one assignment so that they have a final score. The *experimental group* consist of 1st year university students (freshmen) majoring economics, business administration and management, accounting and finance, or economics and international business. 131 students enrolled initially and 123 completed at least one assignment so that they have a final score. Both groups have separated spaces in the virtual classroom so that a student of one group does not know about the activities on the other group. Groups are also physically distant as teaching takes place in different campuses and cities. The same instruments and evaluation criteria were used to compute scores of students of both groups. The experimental and control groups were chosen randomly. Unfortunately we were not able to assign individual students to each group as they freely enroll in the group that they prefer. This decision is mostly made based on their major as the faculties/buildings schedule the groups for their students.

The gamified version of the course includes 36 challenge achievements (grouped in 9 challenges/activities), from which students get trophies after completion, and 7 participation achievements from which participants get medals. All content challenges were created using exactly the same contents of the activities available in the traditional non-gamified version of the course. Students in the experimental group have access to both versions of every activity. Traditional activities are delivered using PDF files. Students of the experimental group received an introduction of 1 hour to the gamification plug-in by the teacher. After that, they have the opportunity to decide freely which set of activities they prefer to use and also to combine them as they want. If they want to use the gamified version they are just asked to register and upload their own avatar (a picture) the first time they connect. On first connection students are shown an introductory screen with a text based tutorial that highlights plug-in features and explains how to use it. Technical support was also available during the course.

The plugin conveniently registers the activities of students on the gamified version. 58 students of the experimental group registered to use the gamified version of the course. 27 students got 8 or more trophies and medals (i.e. completed 8 or more achievements). Teachers indicated that 8 is the minimum number of achievements that a student must complete to consider that she followed the gamified version. This is just to be sure that she completed activities of at least 3 different modules, but it will also offer a new dimension for analyzing the results as it permitted researchers to distinguish between those students who followed the gamified experience and those

who did not. It also permitted getting information on academic results as well as quantitative data and qualitative impressions about students' interaction both with gamified activities and with traditional courseware. The decision to made participation on the gamified experience optional was partly based on this but also on institutional requirements. Making participation mandatory would have supposed to do so for all students in all groups thus hindering experimental design.

7. RESULTS

All the experiments and grading were conducted during the 2011/2012 spring semester. Outcome data collected of the experimental and control group is presented and discussed in this section. It must be borne in mind that teachers provided a grade for each evaluation item of each student along with a final mark for the whole learning experience. Students' opinions were also appraised in an attitudinal survey. All grades were normalized in the range 0-100 for statistical analysis.

7.1. Achievement of Students

Independent-2-sample t-tests indicate that there is no significant difference in the initial knowledge of students in each of the four modules that was assessed (table 1). Post-test results suggest that there is significant difference in six scores (table 2). Students of the experimental group get scores that are significantly higher in the initial activity (p=.004) and also in the practical exercises about spreadsheets (p=.007), software presentation (p=.000) and databases (p=.000). On the contrary, students of the experimental group get significantly lower scores on the final examination (p=.006) and on the participation score (p=.000). Finally there is no significant evidence to support that the experimental group performs better on the exercise on word processing (p=.090) and on the final score (p=.090). Results of the most significant scores are also presented graphically in figure 6.

Table 1. Scores in the initial activity for each module.
Significance was computed using independent-2-sample t-tests.

Evaluation Item	Group	n	Mean	Std Dev	Significance
Word processor	Control	62	44.13	17.68	F=2.20 p=.141
	Experimental	111	49.92	16.53	
Spreadsheet	Control	62	53.32	17.68	F=.62 p=.432
	Experimental	111	56.27	12.95	
Presentations	Control	62	44.52	13.14	F=.49 p=.487
	Experimental	111	46.54	12.17	
Databases	Control	62	52.76	17.19	F=1.36 p=.244
	Experimental	111	56.01	17.75	

Table 2. Final scores for the experimental and control groups.
Significance was computed using independent-2-sample t-tests.

Evaluation Item	Group	n	Mean	Std Error	Std Dev	Significance
Initial Activity	Control	73	77.29	2.41	20.63	F=8.43
	Experimental	123	88.46	2.59	28.75	p=.004
Word processor	Control	64	56.33	2.34	18.73	F=2.90
	Experimental	113	64.01	2.63	27.98	p=.090
Spreadsheet	Control	64	62.70	3.21	25.67	F=7.48
	Experimental	110	73.94	2.52	26.40	p=.007
Presentations	Control	66	64.59	1.52	12.38	F=178.48
	Experimental	110	89.86	1.15	12.01	p=.000
Databases	Control	65	40.25	2.84	22.86	F=56.12
	Experimental	106	69.65	2.53	26.09	p=.000
Final Examination	Control	68	64.12	1.66	13.67	F=7.78
	Experimental	106	58.05	1.38	14.21	p=.006
Participation	Control	73	86.53	2.42	20.67	F=97.47
	Experimental	123	48.13	2.63	29.15	p=.000
Final	Control	73	56.27	2.17	18.58	F=2.90
	Experimental	123	61.57	2.02	22.41	p=.090

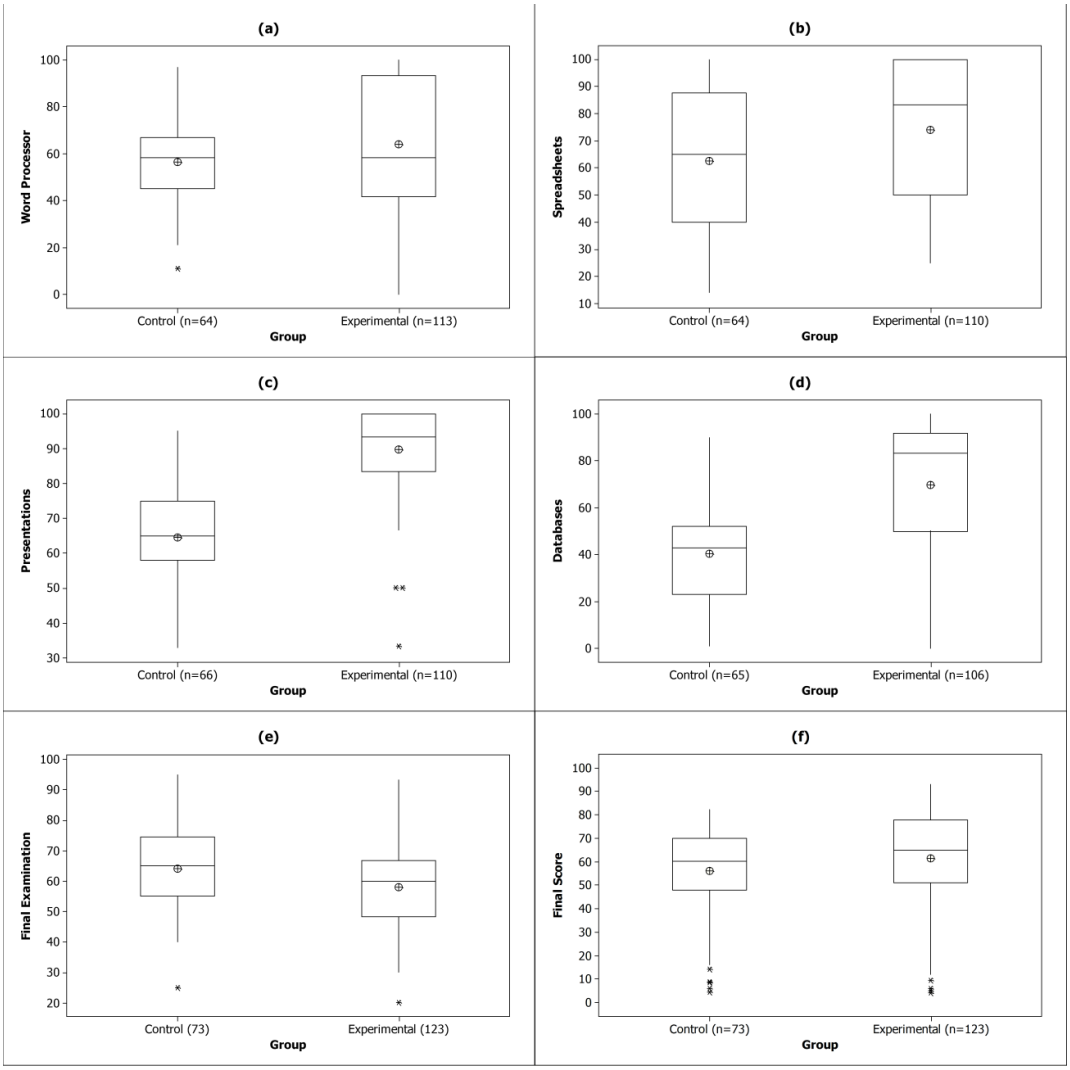

Figure 6. Boxplots of the most significant scores.

One-way analyses of variance (ANOVA) are used to determine the existence of significant differences considering three groups: the control group, the experimental non-gamified group, the experimental gamified group. Results (table 3) are similar to those obtained distinguishing just two groups. The difference in the final score is now statistically significant in at least one of the groups. Confidence intervals (Figure 7) show this graphically and suggest that students who get 6 or more achievements in the gamified system also get significantly higher final scores. Interval plots for the final examination score (Figure 8) and for the participation score (Figure 9) also suggest that the non-gamified experimental group have significantly lower scores than the other two groups and consequently there is no evidence that can confirm that the gamified experience yields worse results in written examinations or somehow prevents students from participating in class activities.

Table 3. Final scores for the control, experimental non-gamified and experimental gamified groups.
Significance was computed using one-way ANOVA tests.

Evaluation Item	Group	n	Mean	Std Error	Std Dev	Significance
Initial Activity	Control	73	77.29	2.41	20.63	F=5.85 p=.003
	Experimental non-gamified	96	86.25	3.12	30.62	
	Experimental gamified	27	96.30	3.70	19.25	
Word processor	Control	64	56.33	2.34	18.73	F=2.53 p=.083
	Experimental non-gamified	88	61.70	3.06	28.68	
	Experimental gamified	26	69.36	5.41	27.60	
Spreadsheet	Control	64	62.70	3.21	25.67	F=4.46 p=.013
	Experimental non-gamified	83	72.25	2.90	26.37	
	Experimental gamified	27	79.14	5.06	26.29	
Presentations	Control	66	64.59	1.52	12.38	F=93.13 p=.000
	Experimental non-gamified	84	89.11	1.40	12.58	
	Experimental gamified	26	92.31	1.67	8.53	
Databases	Control	65	40.25	2.84	22.86	F=28.17 p=.000
	Experimental non-gamified	80	68.77	2.91	26.05	
	Experimental gamified	26	72.37	5.21	26.55	
Final Examination	Control	68	64.12	1.66	13.67	F=3.99 p=.020
	Experimental non-gamified	81	57.67	1.60	14.39	
	Experimental gamified	25	59.27	2.77	13.84	
Participation	Control	73	86.53	2.42	20.67	F=82.14 p=.000
	Experimental non-gamified	96	40.52	2.51	24.64	
	Experimental gamified	27	75.19	5.43	28.20	
Final	Control	73	56.27	2.17	18.58	F=4.85 p=.009
	Experimental non-gamified	96	58.99	2.39	23.43	
	Experimental gamified	27	70.71	2.99	15.52	

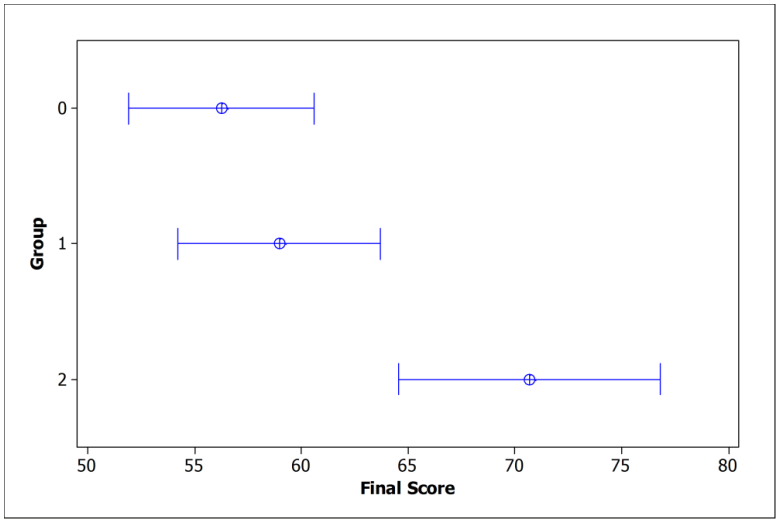

Figure 7. Interval plot of the final score (95% CI for the mean).
0-Control group, 1-Experimental non-gamified group, 2-Experimental gamified group.

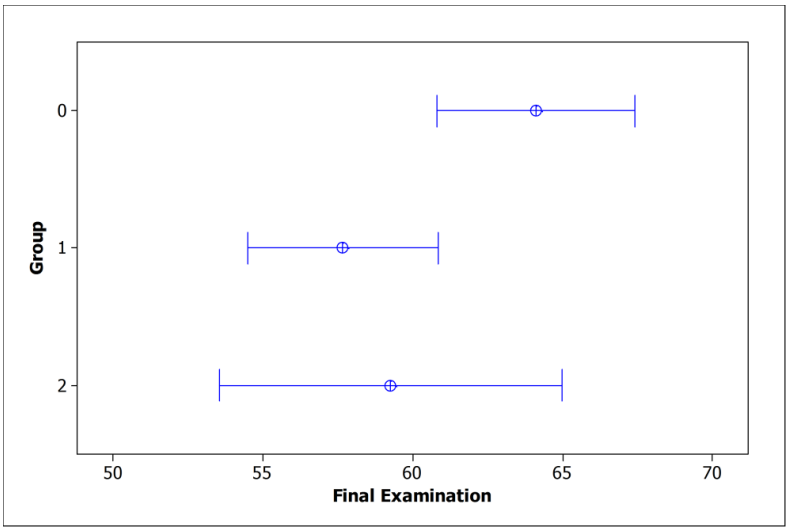

Figure 8. Interval plot of final examination score (95% CI for the mean).
0-Control group, 1-Experimental non-gamified group, 2-Experimental gamified group.

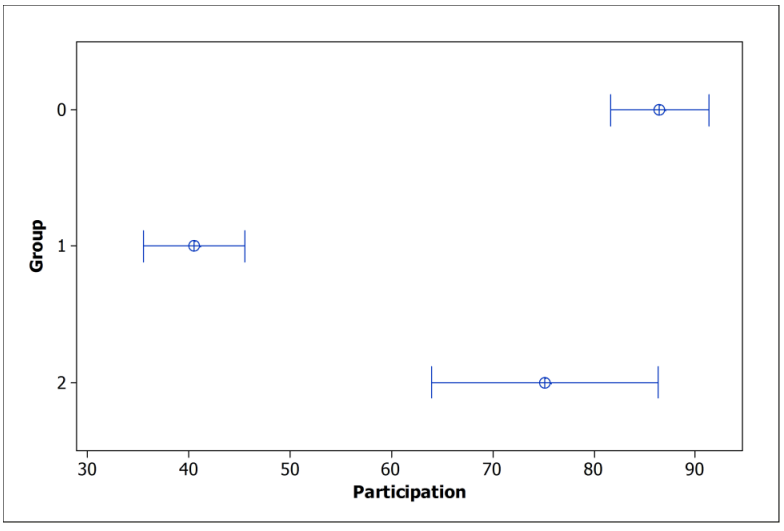

Figure 9. Interval plot of the participation score (95% CI for the mean).
0-Control group, 1-Experimental non-gamified group, 2-Experimental gamified group.

Students on the experimental group performed better on all the items that were concerned with practical application of concepts. On the other hand students in the experimental group performed lower than the control group on the written examination and participation. We think that such differences may be caused by the distinctive nature of the elements being assessed on these items and by the kind of learning fostered by each instrument. In the written examination students are asked mainly about concepts and about the relation of these concepts to practice. On all other evaluation items (except participation) assessment is based on competencies and students are required to know how to complete different tasks using a given application. Considering the results obtained, we can argue that gamified activities help to develop practical competences but somehow they also hinder the understanding of underlying theoretical concepts in contrast with traditional courseware. This conclusion was also drawn by previous work and it has even been identified as a trend by Ke's (2009) meta-analysis who suggested that learning games foster high-order thinking more than factual knowledge.

As for participation, this item was assessed mostly in an objective way based on the number of interactions with the learning platform, contributions to forums and other participative media, and attendance and exercises completed both online and in the classroom. It is tempting to argue that the lower marks got by students in the experimental group are due to the alienating nature of videogames. This is aligned not only with popular culture but also with heideggerian philosophy on alienation through technology. Defendants of this standpoint will argue that the gamified activities while fostering competence acquisition also split in or separate students from reality thus reducing their overall interaction with other students and systems. It is worth mentioning that Heidegger (1977) perspective is that technology is not alienating *per se*, but only when *enframing* (i.e. when the other is treated as an object, rather than as a subject) occurs as a consequence of technological mediation. Our point is that such questions have a very strong philosophical underpinning and that further research and enquiry shall be performed before drawing unsustained conclusions. Particularly, studying approaches that circumvent enframing by carefully addressing social interaction seems promising. Furthermore, a closer examination of data when considering three groups (experimental gamified, experimental non-gamified and control) reveals that the real difference is between the non-gamified experimental (M=40.52, SD=24.64) and the control group (M=86.53, SD=20.67) and it is very substantial. The experimental gamified group also performs lower (M=75.19,

SD=28.20) than the control group but there is no statistical significance. To be honest we have to say that we do not find any explanation for such an important difference. Courseware and methodology were exactly the same for experimental and control groups. The only difference was in the participating teachers as the number of students and groups required the participation of different teachers. Regular meetings were kept to ensure consistency between groups. So in our opinion we can only infer that either the teachers of the control group managed to keep their students participant or the students of the experimental group were really under-participative.

7.2. Attitudinal Survey

The students of the experimental group were also asked to answer a questionnaire of 10 items designed to evaluate their attitude towards the learning tool and their satisfaction level. The instrument used was a questionnaire based on a five-point Likert scale with all the sentences scored in a positive scale. Similar instruments have been used by other researchers (Garrido, Grediaga & Ledesma, 2008). The survey was answered anonymously. 45 students claimed to have followed the gamified experience and provided feedback. Questions and results are summarized in table 4. The average for these questions is 3.64 on the five-point scale, indicating that the students' attitude to this experience was positive. The highest rated statements are items 6 and 7 suggesting that the activities were successfully designed according to students' perception. The ratings of items 2, 9 and 10 are especially significant because they provide a general positive estimation of students' motivation and students' attitude towards learning with this tool, not only during the learning experience but also in the future. In contrast, the lowest rated statement is item 4 which suggest that additional work to improve the usability of tool should be undertaken. Authors can only conjecture to what extent the integration of the tool in the BlackBoard system has an important role in this rating. Low rate on statement 8 indicates a low level of involvement. Regarding this, students were also asked to provide a percentage (0-100) estimating to what level they have completed the gamified activities. Results return a mean of 55.56 (SD=21.56). We can contrast this with real data as the tool records every challenge and achievement completed by students. If we consider all the students who completed at least one gamified activity (N=58) the mean is 22.65 (SD=26.74) and considering only the students (N=27) who completed 8 or more gamified activities (18.6%) the mean is 40.91 (SD=29.59). So in our opinion students' estimation about their own work is (very) optimistic and participation rates are really low. We think that both researchers and teachers shall try to find ways to design new experiments and learning actions in

which participation and its promotion play a central role since this is critical to evaluate learning activities and also to foster meaningful and efficient learning.

Table 4. Questions and Results of the Attitudinal Survey.
Answers were provided in a five-point Likert scale
(1-Strongly Disagree, 2-Disagree, 3-Undecided, 4-Agree, 5-Strongly Agree).

Item	N	Mean	Std Error	Std Dev
#1 Content was presented effectively	45	3,64	0,13	0,89
#2 I learned about the course topic	45	3,76	0,129	0,86
#3 I enjoyed the experience	45	3,49	0,15	0,99
#4 Using the tool was easy for me	45	3,24	0,18	1,15
#5 The proposed practical activities were useful	45	3,56	0,15	0,99
#6 There was a sufficient number of exercises	45	3,91	0,13	0,90
#7 There was sufficient time to complete the exercises	45	3,98	0,15	0,99
#8 My level of involvement was high	43	3,40	0,13	0,85
#9 I would like to learn more about the course topic	44	3,63	0,15	0,99
#10 This was a worthwhile learning experience	45	3,76	0,15	0,98
Average	-	3.63	-	-

Answers variability in the attitudinal survey is low since overall SD is 0.96, which represents less than 1/4 of the mean. So it can be said that the answers are homogeneous. Item correlations are examined to determine the relevance of each item in relation to the other items and the entire survey. All items returned correlation coefficients larger than .4 suggesting coherence in responses. A factor analysis returns a cumulative explanation percentage of variance of 68.5 suggesting that the instrument also presents factorial validity. However, we have to be careful with this values concerning validity since the sample size (45) is considerably lower than the recommendations of standard benchmarks. To complete the analysis, Cronbach's alpha score is computed to measure the internal consistency of the survey. The overall Cronbach's alpha is 0.8629, which is higher than a commonly used benchmark value of 0.7. This suggests that the items measure the same construct.

57 students acknowledged to have not used the gamified version and were asked about the reason/s that prevented them from taken part in the gamified experience. Results are summarized in table 5. Time availability is the most frequent reason argued by students. Technical problems are the second most important reason. The reason argued less frequently is the difficulty to use or understand the system, in marked

contrast to the attitudinal survey in which tool ease-of-use is the lowest rated item. Under 'other reasons', students point out additional problems. Some examples are: "Too many students", "I have to visit too many web pages and applications in the university and I did not want a new one" and "I do not like competition between students and that everyone can see it."

Table 5. Reasons for not using the gamified version (N=57). Students could point more than one reason.

Answer	Frequency
I do not know about them	9
I am not interested in them	6
I do not have time to complete the activities	34
I find technical problems	13
The system is difficult to use / understand	3
Other reasons	17

Another informal questionnaire was included in the e-learning platform asking students whether they found it more motivating to complete gamified activities in contrast with the traditional version, and about which specific elements of the plugin have the biggest motivational impact. 91 students provided feedback using this instrument. Concerning motivation students were asked if they found the gamified activities more motivating, if they found the traditional activities more motivating or if they found the gamified activities neither more nor less motivating that the traditional ones. 29 students (31.87%) found the gamified activities more motivating, 56 students (61.54%) found the traditional activities more motivating and 6 students (6.59%) felt no differences in their motivation. We can consider these figures to be consistent with the previous ones since the number of students that found it motivating is similar to the number of students (27) that completed a reasonable number of gamified activities. Thus, students that followed the gamified course seem to be motivated but further questions remain unanswered about students that did not start or quitted. The reward-based system programmed on the e-learning plugin is designed to improve extrinsic motivation. Although it can be a powerful force to drive intrinsic motivation, several problems have been reported concerning extrinsic motivation. First, participants can feel manipulated. Second, little or no transfer can occur if behavior is only driven by rewards. And finally, if the reward vanishes so does the behavior. In this way, the learner may become too dependent on the reward or she may be not interested at all on it (Lepper, 1988). We conjecture that students who did not follow the gamified approach or quitted were partly not attracted by the reward mechanics implemented.

Nonetheless, we think that this was not the only reason but rather that the other reasons argued by students and the lack of immediate feedback also contributed to the low motivation level observed.

7.3. Qualitative analysis

Finally, students had different opportunities to provide additional feedback about their perceptions and attitude towards the system and the learning experience. In the anonymous attitudinal survey there was an open question in which students were asked to provide any comment or suggestion. 17 students provided feedback using this mechanism. The e-learning platform also provided a source of permanent communication between teachers, researchers and students. Forums were used as a source of feedback and a specific feedback form was also available in the e-learning platform. Teachers and researchers analyzed all elements to create also a qualitative appraisal of students' perceptions and motivations.

In general we got numerous positive responses. The following comment can be taken as an example. It stresses the importance of the leaderboard and also the fact that, as for all activities, completing them was a way to contribute to the participation score: "I have completed the gamified activities because by means of the leaderboard, global statistics, …; I can know what is the amount of work that I have done with respect to other students. The fact that my activities were also contributing to the participation score also influenced me." The following reflection is representative of the possibility to choose between both versions of the activities. The student asserted that he had completed the gamified activities "because the leaderboard was motivating for me, and also as I was going to complete the activities in any case, I preferred the gamified version." Another student interestingly commented: "I preferred to make the gamified ones. Decision that I have taken for the simple reason that by completing them, but previously done them in the traditional way as the instructions are better, and then submitted to the new virtual platform to win new points as it is fun and motivating in many ways, be it for the graphics, the trophies … and it is even more colorful and encouraging." Here the student is presenting his experience as a combination of both approaches (traditional and gamified). He prefers the traditional approach to go through the activities, but finally he completes them in the gamified version because he finds it motivating, encouraging and even 'colorful'. These as well as similar comments stress the importance that competition has for some students as well as the chance to have

the same contents in different formats which can be combined to create meaningful and motivating learning experiences.

Contrasting with positive comments, we also found opposing opinions. We found especially interesting those that reflect about the dislike and uneasiness created by the leaderboard and the feeling of competition among students. For instance, this student states "I prefer traditional activities because I don't think that leaderboards are a good representation of who gets more knowledge about the course" or another student who states, "I think that it would be more interesting to improve the traditional version, instead of making competitions." We mentioned above that similar statements were argued among the reasons for not using the gamified system. All other negative perceptions can be categorized in three groups: (1) preference for traditional-like activities because "they are easier" or "I feel more comfortable with them", (2) "I did not have time, and I didn't know what difficulties I was going to find", and (3) "By having the option of the normal system, the game I thought it would take longer."

8. CONCLUSIONS AND FUTURE WORK

Gamification in e-learning platforms seems to have potential to increase student motivation, but it's not trivial to achieve that effect, and a big effort is required in the design and implementation of the experience for it to be fully motivating for participants. On the one side, experiment qualitative analysis suggests that gamification can have a great emotional and social impact of students, as reward systems and competitive social mechanisms seem to be motivating for them. Reward systems suppose an innovative, fun and encouraging way to represent progress within an online educative experience. Leaderboards also serve as a source of motivation because students see their work publicly and instantly recognized, and because they can compare their progress with other classmates. These good results don't happen for everyone though. For many, the system was not motivating enough to participate along the course. In some cases the system was even discouraging, as some students don't find it fun to compete with their classmates for a rank in the leaderboard. Our work is influenced by studies on the profiles of players who foster competition. For instance, Heeter, Lee, Medler & Magerko (2011) identify four types of players based on performance and mastery levels of achievement goals, namely: performance-only players, mastery-only players, non-achievers and super-achievers. Arguably, other styles of players, like socializers or explorers, have to be considered. Our future work will try to address these issues, reducing the overall importance of competition and rewards, and

introducing cooperative and social mechanisms which are currently being used in the so called "social games" (Hicks, 2010). We will also try to find new ways of gamification that are more meaningful to the students, not limiting the system to extrinsic rewards like achievements and badges, as suggested by Deterding in his presentation "Meaningful Play: Getting gamification right"[5], and by Nicholson in his User-Centered Theoretical Framework for Meaningful Gamification (Nicholson, 2012).

On the other side, quantitative analysis suggests that cognitive impact of gamification over students is not very significant. Students who followed traditional exercises performed similarly in overall score than those who followed gamified exercises. From our point of view, cognitive characteristics of videogames that create the so called "cycles of expertise" (Gee, 2003) that further derive into "flow experiences" (Csikszentmihalyi, 2008) are in the very nature of the medium, and cannot be exported to traditional educative content by any way without entering in the field of edutainment or serious games. Although gamification impact on the cognitive aspects of educative content is limited, we still think that changing content design and structure to make it more fun can have great motivational impact. One suggestion is to design educative exercises embracing from the very beginning the concept of gameful design (Deterding, Dixon, Khaled & Nacke, 2011) to make them more interesting for students. Additionally, we shall consider a more systematic approach for the design and evaluation of gamified learning. We shall take previous work on evaluation frameworks in game-based learning, e.g. (de Freitas & Oliver, 2006), as a starting point. This will enable us to extract more solid conclusions about the reality of gamification in education.

Apart from exposed lines, students reported other design and technical issues that should be addressed in future works. Some of them complained about the Blackboard plugin because it was hard to use or didn't work well. Although students were introduced to the plug-in by the teacher and by a textual tutorial, it seems that those introductions were not good enough for all students to be able to use the plug-in proficiently. On future versions, we might consider including an interactive introduction which not only explains, but also guides students step by step on plug-in features usage. Some important technical problems may be related to the Blackboard platform, as it introduces network overload that slowed down screenshot uploading, making it

[5] Meaningful Play: Getting Gamification Right.
http://www.youtube.com/watch?v=7ZGCPap7GkY

tiring and time consuming. The proprietary code of Blackboard platform made it impossible for us to fix this, and we didn't manage to find a workaround solution. Other potential issues may have risen with an appropriate usability and software testing process. An important conclusion that students' reports suggest is that a good testing process is essential when developing a gamification system; otherwise its motivational effects can be dramatically diminished by unaddressed usability and technical issues.

Another important problem was task evaluation. Many students didn't complete gamified exercises because they thought that it was a waste of time to capture and upload screenshots of their work. This may also be related to the technical issues that slowed down screenshot uploading, but it was not the only problem. Participants also reported that as they could upload empty screenshots to obtain achievements in an attempt to cheat. Finally, teachers had to do additional efforts to correct all the screenshots in order to validate student's achievements. All these facts indicate that gamification has some limitations when tasks cannot be automatically evaluated by the e-learning platform as a conflict arises between immediate feedback, fair rewards and teacher effort. We think that immediate feedback will increase students' motivation yielding better results. This is a critical aspect of videogames that makes them compelling and engaging so gamified initiatives must address it (Kapp, 2012). As future work we have to design new methods to automate the work that teachers must do, and also develop the tools to enable them to create and modify the gamified learning experiences easily, making the underlying technological infrastructure transparent. Unsupervised scoring systems (Goldberg & Song, 2004) may also be an interesting solution to this problem, and response-driven feedback approaches (Fernández-Alemán, Palmer-Brown & Jayne, 2011) can help teachers to produce meaningful and rapid feedback

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2.3. Resumen de los resultados del artículo 1

En este capítulo hemos mostrado los efectos de una herramienta de gamificación en el rendimiento académico de los alumnos en un contexto de formación universitaria semipresencial, siendo utilizada como complemento opcional al sistema e-learning tradicional. Los resultados del experimento sugieren que el diseño utilizado en el instrumento experimental habría tenido un efecto positivo en la adquisición de habilidades prácticas, pero negativo en el aprendizaje de conceptos teóricos, siendo en todo caso un efecto poco significativo en términos generales. El experimento también sugiere que la gamificación, por si misma, no tiene por qué resultar atractiva o motivadora para los alumnos, tal y como muestran el bajo nivel de uso de la herramienta por parte de una mayoría. De forma general el experimento muestra que la gamificación puede tener efecto en el rendimiento académico, pero que, para que este pueda llegar a ser significativo, resulta necesario un gran esfuerzo de diseño así como una adecuada alineación de la herramienta y sus contenidos con los objetivos académicos y criterios de evaluación. De otra forma la gamificación puede llegar a tener efectos contraproducentes para el aprendizaje.

Después de analizar los efectos de la gamificación en el rendimiento académico, exploraremos el uso de un instrumento de motivación alternativo y bien estudiado, las redes sociales, para compararlo con el primero. Las redes sociales se caracterizan por el uso de mecanismos de motivación e interacción de carácter social, en vez del carácter competitivo u orientado al logro de algunos mecanismos de gamificación. Su efecto en el aprendizaje ha sido estudiado en numerosas ocasiones con resultados positivos. En el próximo capítulo analizaremos y compararemos los efectos de ambos instrumentos en un mismo contexto académico.

Capítulo 3

Comparativa entre los efectos del uso de gamificación y redes sociales en el aprendizaje

3.1. Contribución del artículo 2

La gamificación podría tener un gran potencial como instrumento para mejorar la motivación y los niveles de participación en la educación a distancia. Sin embargo, en la práctica nos hemos encontrado con diversas limitaciones que hacen difícil explotar dicho potencial. Entre otras, los mecanismos de motivación analizados hasta el momento no parecen ser efectivos ni motivadores para un número significativo de alumnos. Una de las posibles razones es su carácter competitivo y orientado al logro. Tal y como muestran los resultados cualitativos del estudio anterior, algunos alumnos consideran que estos mecanismos son negativos para su motivación al fomentar la comparación social con sus compañeros. Algunas teorías sugieren que, en contraposición, los mecanismos de motivación basados en la cooperación y la socialización podrían resultar más motivadores, fomentando la interacción entre alumnos y el aprendizaje colaborativo.

Uno de los instrumentos más indicados para probar la bondad de estas ideas es el de las redes sociales, plataformas que ofrecen múltiples características destinadas a facilitar la interacción entre usuarios. Las redes sociales han sido estudiadas en numerosas ocasiones y sus efectos en el plano educativo son bien conocidos tanto a nivel teórico como experimental. Comparar ambos instrumentos, gamificación y redes sociales, en el mismo contexto educativo, sería de interés para entender mejor los efectos que distintos tipos de instrumentos de motivación pueden tener en los alumnos. Esta comparativa también aportaría información sobre los posibles beneficios de la gamificación social respecto a un enfoque de gamificación competitivo u orientado al logro.

En este capítulo abordamos esta tarea, exponiendo y comparando los resultados obtenidos tras el uso de una red social y una plataforma e-learning gamificada en distintos grupos de una misma asignatura universitaria semipresencial.

3.2. Artículo 2

A continuación se incluye el artículo 2, “An empirical study comparing gamification and social networking on e-learning”, en su versión pre-print.

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An Empirical Study Comparing Gamification and Social Networking on e-Learning

Abstract: While social networking has already demonstrated its efficiency in e-learning, gamification, which is the use of game-thinking and playful design in non-game contexts, has only shown its potential as a motivational tool. This paper presents the results of testing both social networking and gamification in an undergraduate course, comparing them in terms their effect on students' academic achievement, participation and attitude. The effects of a gamification plugin deployed in a learning management system were compared to those of a social networking site in the same educational setting. We found that both approaches presented better performance than a traditional e-learning approach in terms of academic achievement for practical assignments, but that, when it came to assessing knowledge, the traditional e-learning approach was better. Also challenging current assumptions, participation rates and scores remained low with the new tools, although students' attitudes were positive.

Keywords: Gamification, playful design, social network, e-learning, achievement, participation

1. INTRODUCTION

Gamification is the use of game elements and game-design techniques in non-game contexts to engage people and solve problems (Werbach & Hunter, 2012, Zichermann & Cunningham, 2011, Deterding et al., 2011). Games present clear objectives, which are further divided into short-term achievable goals that give a seamless sense of progression to players by providing frequent rewards that act as external motivators. Advances in information and communication technology have enriched games by endowing them with instant feedback and instant connection with other players. Videogames are part of a multidisciplinary, growing and leading industry attracting talented designers, artists and programmers alike (Chatfield, 2010). Harnessing the ability of videogames to promote creative thinking and productivity could lead to new ways of tackling real world problems. Videogame advocates suggest that videogames can have a real impact on everyday activities and that they have the potential to make a better world (McGonigal, 2011). Besides, game-based learning has already shown the potential of videogames to broaden audiences and integrate disadvantaged target groups, thus making education more accessible (Kam et al., 2008, Schmitz et al., 2011).

Gamification is currently driven by the success and momentum of videogames but it also draws on different psychological theories, mostly using motivational models. Self-determination theory (Ryan & Deci, 2000) identifies two types of motivation, extrinsic and

intrinsic, and depicts a sort of continuum from one to the other. Gameful design should strive for intrinsic motivation, which is the kind of motivation in which the activity is rewarding in and of itself. Offering rewards is a kind of extrinsic motivation and this can be used to engage participants, but only as a tool towards promoting authentic intrinsic motivation in which the activity itself becomes the reward.

Use of gamification may have great potential in traditional education where we often find students demotivated and lecturers failing to engage them in learning activities. This is also true in e-learning where mediated communication, lack of eye contact and lack of direct exposure of students to a teacher's expertise can aggravate the problem (Flores, 2012, Dreyfus & Dreyfus, 1986). In current work on the application of gamification to teaching and learning, Haksu and Young (2012) describe how to design learning activities using a gameful design approach, Raymer (2011) provides suggestions on how to engage and promote participation through e-learning systems, Erenli (2012) reflects on the impact and soundness of gamification in teaching from a teacher's perspective and Simões et al. (2013) present a framework aimed to help teachers integrate game elements in learning activities which are validated in real scenarios. Gamification in education is "a serious approach to accelerating the experience curve of learning, teaching complex subjects, and systems thinking" (Kapp, 2012: p. 13), but there is little, if any, solid empirical evidence of gamification's effectiveness in education. Empirical studies seem to question such effectiveness, especially in e-learning settings, pointing to the potential problems that students and instructional designers face (Domínguez et al., 2013). Other studies of gamification in education have found that it is effective in terms of engaging students in non-curricular activities (Fitz-Walter et al., 2012) and promoting behavior changes in order to increase participation in peer tutoring sessions, something which is ultimately reflected as an increase in the passing percentage (Decker & Lawley, 2013).

In contrast, social networking has a well-established body of theoretical and empirical knowledge regarding its effectiveness in e-learning settings. Existing studies have showed the influence of students' online social networking in their social learning and academic learning (Tian et al., 2011) and have also found correlations between usage levels and perceived levels of learning (Thoms, 2011). Furthermore, it has been found that social network properties (e.g. centrality) significantly influence learners' performance (Cho et al., 2007, de-Jorge-Moreno, 2012).

This paper compares both approaches, gamification and social networking, empirically in an introductory course on information technology. We designed and tested two different instruments that were intended to deliver mechanisms for motivation and participation. The first tool was a gamification plugin built into the learning management system. It offered rewarding opportunities for engaging in course activities along with room for competition between students. The second tool was a networking site that provided a solid ground for collaboration, interaction and discussion with other participants around the course materials. Our aim was to compare both approaches in the same study site to determine their effectiveness in terms of achievements of students, levels of participation and engagement and students' attitudes towards each tool. The rest of the paper is structured as follows: Section 2 presents the experimental design, describing the experimental setting, instruments and methodology; Section 3 presents the results of students' achievement, participation and perception and Section 4 presents conclusions, discussion, limitations and further research lines.

2. EXPERIMENTAL DESIGN

2.1. Study Site

Qualification for Information and Communication Technologies (ICT) is an undergraduate course that covers the basics of information and communication technologies and provides students with basic competency with the computer and office applications. The course lasts for 15 weeks and it has a workload of 6-10 hours per week. It includes the following modules: (1) ICT, the computer and its components, (2) operating systems, (3) word processing, (4) spreadsheets, (5) presentations, (6) databases and (7) networks and communication. The syllabus is based on the European Computer Driving License (ECDL) and the International Computer Driving License (ICDL) programmes[1]. ECDL / ICDL are intended to become de facto standard certifications of digital literacy and competency.

The course uses a blended learning approach where students have three hours of lecture every week. Lectures are complemented with previous readings and activities, which are delivered online through the BlackBoard learning management system. Each module includes two or three activities that introduce students to the main concepts in a practical way and therefore represent the core of the learning experience. Activities are introduced in the lectures, but students have to complete them outside the lab. Students

[1] ECDL Foundation. ECDL / ICDL programmes: http://www.ecdl.org/programmes/ecdl_icdl

have textual descriptions of the activities as well as sample solutions. Evaluation items for the course include four assignments to assess the skills and competencies of modules 3, 4, 5 and 6, and a final examination to assess knowledge covering all contents but focusing on modules 1, 2 and 7. Students are also credited for participation in class as well as on the e-learning platform and can get up to 5% for completing online activities and tests, contributing to forums, etc. Experience from previous classes had shown low completion rates for activities, which were subsequently reflected as poor performance records. Providing students with tools to motivate participation may therefore be a sound approach to improve involvement and performance.

2.2. Research Questions

Our year-long experiment looked to explore the following research questions:

1. Will gamification and/or social networking impact learning in large classroom environments?
2. Will gamification and/or social networking impact participation rates?
3. Will students have a positive attitude towards these tools?

2.3. Instruments

In order to compare the performance as well as the attitude of students towards gamification and towards social networking, we devised two systems that allowed students to interact with the course materials and with other students. The first instrument was a gamification plugin deployed in the BlackBoard system, which allowed students to complete course activities and compete and collaborate with other students. Each activity was presented as a challenge and divided into levels (three or four per activity depending on the activity's complexity), thus giving students a sense of progression towards mastery and also providing rewards (trophies) on completion of each level. An example is shown in Figure 1. Eleven activities were gamified providing a basis for earning 36 trophies. All learning modules had their corresponding gamified components (one or two activities per module). Lecturers had to participate in the reviewing process by checking submissions (a screenshot for every level). A badge system was also devised to provide further rewards and social status. Badges were awarded based on completed activities (e.g. Word Master for completing all activities on word processing) and also given based on participation in the e-learning platform (e.g. Rookie, an onboarding badge awarded to any student for just registering to use the plugin). A few badges were hidden to provide a sense of emotion or surprise. Seven badges were designed and included in the system. Finally, the number of challenges completed by

students provided a basis for implementing a leaderboard (Figure 2) that offered an opportunity to compete and compare performance with other students. Discussion forums were also available for students willing to share or cooperate.

Figure 1. Gamification plugin showing a challenge (learning activity) divided in levels and the corresponding trophies that students got after completing each level.

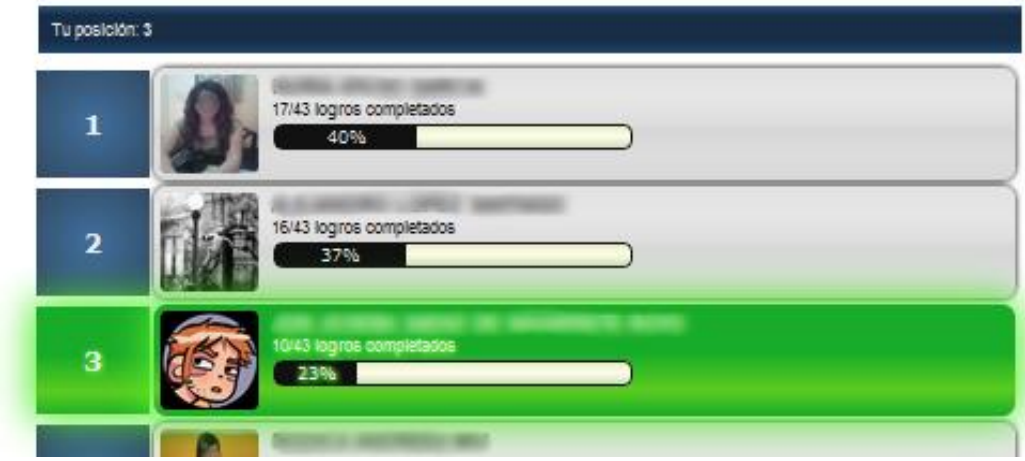

Figure 2. Leaderboard of the gamification plugin presenting the position of the student in relation to other students.

The second instrument was a social networking site delivered as a complement to the e-learning platform (Figure 3). The implementation was based on Elgg[2] and provided the following functionality to students:

- Videos presenting how to perform basic operations with computer tools (e.g. applying styles and creating tables of contents in the word processor), and additional videos providing step-by-step solutions to each activity of the course. Students could also submit any video that they found or produced.

[2] Elgg - Open Source Social Networking Engine: http://elgg.org/

- Blogs in which both students and lecturers had blogging options enabling them to produce entries controlling their visibility (visible to all participants, just followers or private)
- A followers function through which participants could follow other participants and monitor their activities on the site.
- Questions and answers where students could submit questions for other participants to answer. All participants could also rate answers.
- Twitting capability whereby a built-in twitter system was included in the site enabling students to publish short comments at any moment.
- A commenting and liking function in which students could comment on any content in the social networking site and "like" that content.

All learning modules had their corresponding social network components including two or three videos on basic competences and one or two videos providing the solutions to activities.

Figure 3. Social networking site presenting the general dashboard where students could see the latest activity in the platform.

2.4. Methodology

In order to test and compare the tools, we used a quasi-experimental design. Three groups of students were selected and the instruments were applied on two of them. The third group was the control group. The gamification plugin was used on a group of 114 first-year undergraduate students majoring in either economics, business administration, accounting and finance or international business. The social networking site was

delivered to a group of 184 first- and second-year undergraduate students majoring in either life sciences, nursing, economics or business administration. The control group included 73 first- and second-year undergraduate students majoring in either nursing, infant education, primary education, business administration, tourism, or construction engineering. Traditional materials and activities were delivered to all groups alike through the e-learning platform and in the lectures. Engagement with the experimental instruments was optional for students. Students in the experimental groups could participate through the traditional e-learning course, their experimental tool or both. Group selection was arbitrary. Our underlying aim was to provide the experimental tools to large groups to try to have a critical mass of students that could engage with them. Under this premise, we assumed that group size does not have any impact on the control group although ultimately, we were not able to determine the effect of group size on any experiment.

Experiments were run during the spring and fall of 2012. Lectures took place in different spaces for each group (different campuses in different cities) and groups also had separated e-learning courses. Quantitative data about students' performance and participation was collected during each term. A pre-test, post-test experimental design was used to assess and compare students' performance on every evaluation item. Interactive tests were used to assess students' pre-test performance and assignment scores were used as a measure of post-test performance. Post-test data of the final examination and a participation score for each participant were also computed and gathered. The participation score was automatically computed based on attendance at the lectures and contributions to the e-learning course. Engagement with the experimental instruments was scored using the same standards as participation in the e-learning course. Students in the experimental groups had two ways to contribute to their participation scores. All scores were normalized to a 0-100 scale. Pre-test and post-test data were compared using analysis of variance (ANOVA) tests. An attitudinal survey was also used on the experimental groups to gather quantitative and qualitative data about students' perceptions of both instruments. The attitudinal survey comprised 10 items based on a 5-point Likert scale.

3. RESULTS

3.1. Academic Performance

Pre-test results (Table 1) suggest that there is no significant difference between the three groups on the four evaluation items assessed. Post-results (Table 2) suggest that both

experimental groups outperformed the control group on the four practical assignments. When comparing both experimental groups, the social networking group also performed better than the gamification group on the assignments about word processing (F= 54.37, p<.001) and spreadsheets (F= 22.87, p<.001). These were the first evaluation items. There was no substantial difference between both experimental groups on the other two evaluation items (presentations and databases). Surprisingly, students in the control group outperformed both experimental groups in the final written examination. The social networking experimental group also outperformed the gamified experimental group on the final examination (F=7.96, p=.005). Finally, students in the control group got participation scores substantially higher (M=87.73, SD=18.61) than students of the gamified group (M=52.86, SD=26.11) and also higher than students of the social networking group (M=78.04, SD=25.96), and all differences were also statistically significant.

Table 1. Pre-test results of the control and the two experimental groups.
Significance is computed using one-way ANOVA tests.

Learning Objective	Group	N	Mean	Std Err.	Std Dev.	Significance
LO1: Word Processing	Control	62	49.61	1.81	14.28	F= 2,54 p=.112
	Gamif.	111	45.02	1.70	17.95	
	Social	145	48.86	1.66	19.97	
LO2: Spreadsheets	Control	62	55.66	2.09	16.50	F=.25 p=.621
	Gamif.	111	54.01	1.58	16.69	
	Social	146	55.08	1.44	17.40	
LO3: Presentations	Control	62	45.37	1.61	12.72	F=2.54 p=.113
	Gamif.	111	44.99	1.22	12.89	
	Social	146	47.62	1.10	13.24	
LO4: Databases	Control	62	52.76	2.18	17.19	F=.76 p=.469
	Gamif.	111	56.01	1.69	17.75	
	Social	145	55.62	1.45	17.55	

Table 2. Final (post-test) results of the control and the two experimental groups.
Significance is computed using one-way ANOVA tests.

Learning Objective	Group	N	Mean	Std Err.	Std Dev	Significance
LO1: Word Processing	Control	64	56.33	2.34	18.73	F=53.30 p<.001
	Gamif.	111	65.17	2.55	26.86	
	Social	173	85.01	1.41	18.48	
LO2: Spreadsheets	Control	64	62.70	3.21	25.67	F=29.14 p<.001
	Gamif.	110	73.94	2.52	26.40	
	Social	171	86.68	1.39	18.23	
LO3: Presentations	Control	66	64.59	1.52	12.38	F=113.67 p<.001
	Gamif.	110	89.86	1.15	12.01	
	Social	164	88.29	.89	11.41	
LO4: Databases	Control	65	40.25	2.84	22.86	F=38.65 p<.001
	Gamif.	105	70.32	2.47	25.30	
	Social	158	71.38	2.08	26.10	

Final Examination	Control	72	78.36	2.19	18.61	F=37.42 p<.001
	Gamif.	106	58.05	1.38	14.21	
	Social	172	63.24	1.17	15.28	
Participation Score	Control	72	87.73	2.13	18.06	F=53.85 p<.001
	Gamif.	112	52.86	2.47	26.11	
	Social	184	78.04	1.91	25.96	

Pre-test results considering instrument usage (Table 3) showed no difference between all five groups on the four evaluation items. Post-tests results (Table 4 and Figure 4) require closer analysis. The social networking group got better scores on the first two evaluation items regardless of their use or non-use of the social networking site and this difference is statistically significant. For the next two learning objectives (presentations and databases), both groups of regular users outperformed their non-user counterparts although differences were small and not significant. In the final written examination, students of the control group got better scores than any other group. Both groups of users got slightly better scores than non-users, and the social networking group also showed a small positive difference on the score compared to the gamification group. Finally, in the participation score, the social networking group of users performed better than any other group. They were followed by the control group. The groups of gamified users and social networking non-users performed similarly and the gamified non-users got substantially lower scores.

The breakdown of users and non-users in both experimental groups does not account for the unexpected score of the control group on participation and the final exam. As for the final examination score, results suggest that a traditional blended-learning approach that delivers documents for each learning topic as well as textual descriptions of learning activities may be most suited for conveying knowledge acquisition compared to the experimental instruments. The final examination was a multiple-choice test designed to assess knowledge, while all other evaluation items were practical assignments designed to assess competency with information tools. Intervention and the traditional e-learning course were both delivered to the experimental groups simultaneously. So, we think that the overload of having to deal with all the materials may have influenced the results. Particularly, the authors conjecture that because interventions were mostly focused on skill acquisition (practical activities), they tended to focus students' attention in that way and somehow neglected knowledge acquisition. Although additional research will be required to confirm this hypothesis, the results may raise concerns about these approaches and the way in which they are delivered since they may bias students' attitudes and create trade-offs between knowledge and praxis.

Table 3. Pre-test results of the control and the two experimental groups (experimental groups are subdivided into students that did and did not use the tools regularly, gamif. non-use and social non-use, gamif. use and social use).
Significance is computed using one-way ANOVA tests.

Learning Objective	Group	N	Mean	Std Err.	Std Dev.	Significance
LO1: Word Processing	Control	62	49.61	1.81	14.28	F=1.91 p=.129
	Gamif. non-use	85	43.52	1.97	18.19	
	Gamif. use	26	49.92	3.24	16.53	
	Social non-use	92	47.71	2.01	19.25	
	Social use	53	50.87	2.91	21.21	
LO2: Spreadsheets	Control	62	55.66	2.09	16.50	F=.41 p=.748
	Gamif. non-use	85	53.32	1.92	17.68	
	Gamif. use	26	56.27	2.54	12.95	
	Social non-use	93	54.41	1.82	17.57	
	Social use	53	56.26	2.36	17.21	
LO3: Presentations	Control	62	45.37	1.61	12.72	F=1.14 p=.332
	Gamif. non-use	85	44.52	1.42	13.14	
	Gamif. use	26	46.54	2.39	12.17	
	Social non-use	93	47.08	1.25	12.07	
	Social use	53	48.57	2.08	15.17	
LO4: Databases	Control	62	52.76	2.18	17.19	F=.95 p=.436
	Gamif. non-use	85	54.62	1.83	16.87	
	Gamif. use	26	60.54	3.93	20.06	
	Social non-use	93	55.48	1.77	17.11	
	Social use	53	55.85	2.54	18.46	

Table 4. Final (post-test) results of the control and the two experimental groups (experimental groups are subdivided into students that did and did not use the tools regularly, gamif. non-use and social non-use, gamif. use and social use).
Significance is computed using one-way ANOVA tests.

Learning Objective	Group	N	Mean	Std Err.	Std Dev.	Significance
LO1: Word Processing	Control	64	56.33	2.34	18.73	F=28.00 p<.001
	Gamif. non-use	85	63.88	2.89	26.66	
	Gamif. use	26	69.36	5.41	27.60	
	Social non-use	115	82.90	1.75	18.76	
	Social use	58	89.20	2.27	17.32	
LO2: Spreadsheets	Control	64	62.70	3.21	25.67	F=15.09 p<.001
	Gamif. non-use	83	72.25	2.90	26.37	
	Gamif. use	27	79.14	5.06	26.29	
	Social non-use	113	86.17	1.67	17.79	
	Social use	58	87.67	2.52	19.18	
LO3: Presentations	Control	66	64.59	1.52	12.38	F=58.63 p<.001
	Gamif. non-use	84	89.11	1.40	12.85	
	Gamif. use	26	92.31	1.67	8.53	
	Social non-use	109	87.05	1.17	12.25	
	Social use	55	90.75	1.24	9.16	
LO4: Databases	Control	65	40.25	2.84	22.86	F=20.59 p<.001
	Gamif. non-use	79	69.64	2.81	25.02	
	Gamif. use	26	72.37	5.21	26.55	
	Social non-use	104	68.41	2.56	26.12	
	Social use	54	77.10	3.45	25.33	

Final Examination	Control	72	78.36	2.19	18.61	F=19.89 p<.001
	Gamif. non-use	81	57.67	1.60	14.39	
	Gamif. use	25	59.27	2.77	13.84	
	Social non-use	114	61.52	1.37	14.67	
	Social use	58	66.61	2.10	16.02	
Participation Score	Control	72	87.73	2.13	18.06	F=60.83 p<.001
	Gamif. non-use	85	45.76	2.28	21.07	
	Gamif. use	27	75.19	5.43	28.20	
	Social non-use	125	68.96	2.38	26.57	
	Social use	59	97.29	1.02	7.84	

The breakdown for the participation score shows that the social networking group of users got really impressive results, but this seems logical since collaborative environments should increase participation. Unexpectedly, the control group followed and it outperformed the remaining groups. This suggests that traditional e-learning methods provide enough room and tools for students' participation. However, we think that caution should be taken with the measures. Since our aim was to provide comparative results, the participation score was computed using the same standards for the control and experimental groups. These included the number of contributions to the system as well as attendance and participation during lectures and lab sessions. New instruments may provide new means of participation and collaboration that were not measured. This may include promoting interaction with course materials and with peers through using the network or through active searches for information. At the same time, new instruments may also detract from traditional participation in the lectures and lab sessions as students would have more information and materials available (for instance videos) and have access to online feedback from peers and lecturers. Nonetheless, achievement results for the gamified instrument suggest that it does not promote participation, especially among non-users that got significantly poorer scores. In this case our design promoted individual work and competition among students rather than collaboration, and this may have influenced participation scores. Also, students in the experimental groups had two ways to contribute to their participation scores online (in the e-learning platform and in the experimental instrument), but results suggest that this did not provide an important advantage. Hence, the question that remains open is whether the additional ways to contribute decreased participation, or if it was just that students embraced the experimental tools leaving aside traditional ways of participation. To summarize, concerning participation, we conclude that social networking improves participation of active students as measured by classic procedures like attendance and contributions to online platforms, but traditional tools offered by e-learning platforms also yield good results. In contrast, our approach to gamification overemphasized competition, significantly decreasing participation as measured by the same standards.

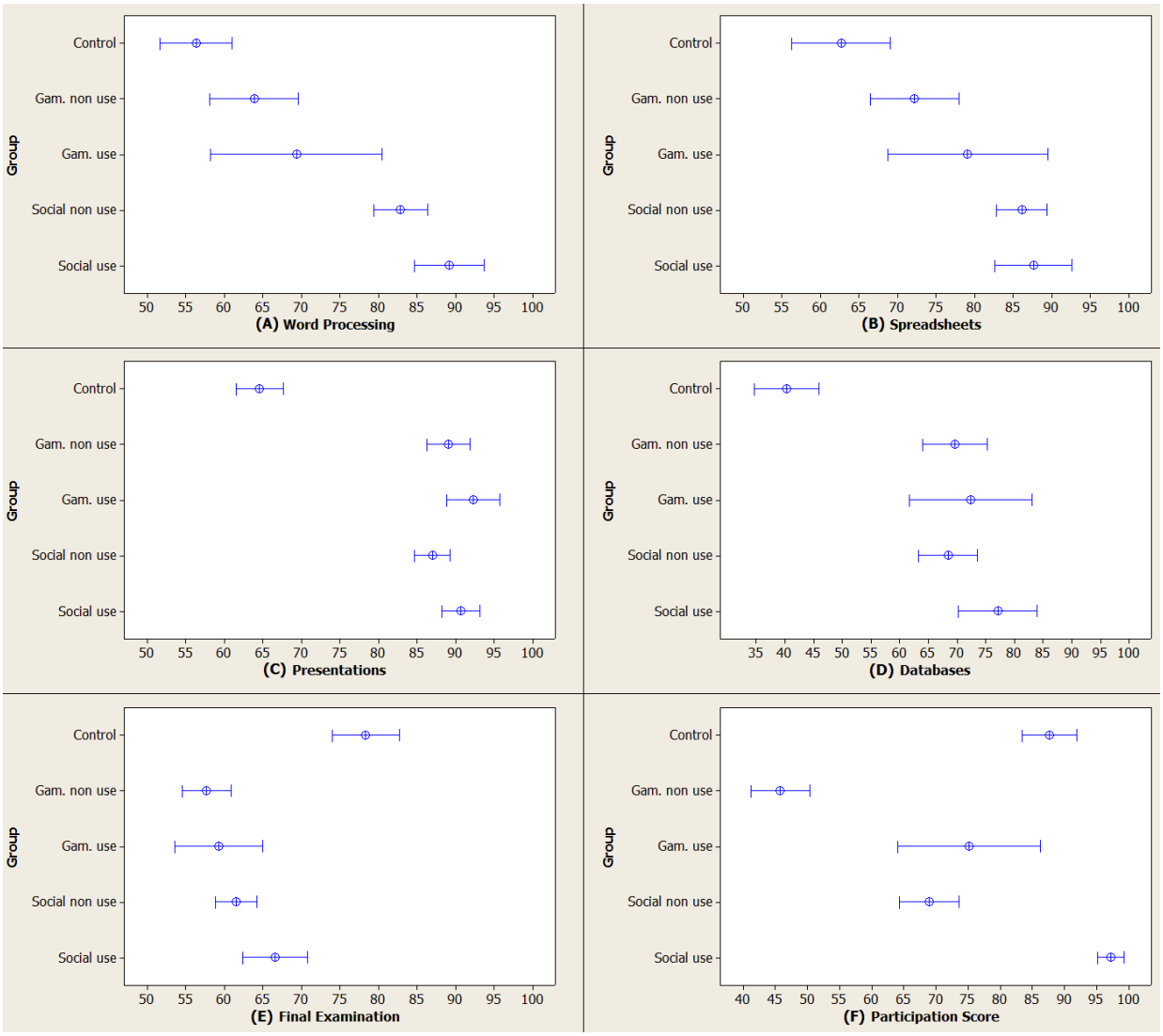

Figure 4. Interval plots of post-test evaluation scores for the five groups for every evaluation item (95% CI for the mean).

3.2. Social network analysis

Links between participants in the social network provided an additional layer of information about involvement with the tool. In a social network graph, participants are represented as nodes and followers are represented as edges between nodes. Figure 5 presents the structure of the final network. 109 participants and 206 edges were created for an average in-degree of 1.86 (i.e. average number of followers per participant). The network had a diameter of 7 and density of .02. Density value is really low even for a social network, meaning that only 2% of all possible links were established. Visual representation shows four relatively unconnected clusters of students with a lecturer in the center. It also shows that many participants, exactly 42, did not establish even a single link.

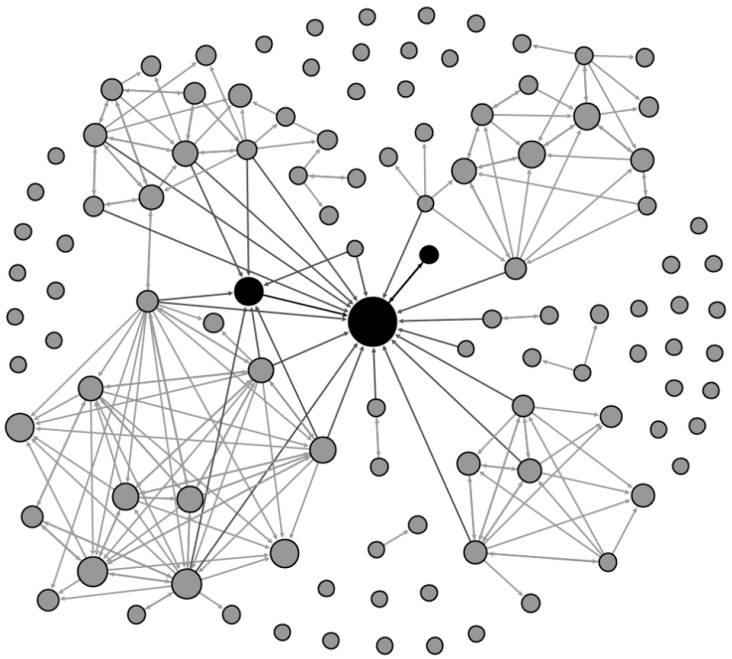

Figure 5. Graph of the social network. Size represents in-degree (number of followers). Dark nodes represent lecturers and grey nodes represent students.

3.3. Attitudinal Survey

An attitudinal survey was run on both experimental groups to evaluate students' level of satisfaction and their attitude towards the learning tools. A five-point Likert scale questionnaire with all questions scored in a positive scale was used. Answers were anonymous. 45 students of the gamified group and 97 students of the social group provided feedback. Questions and results are presented in Table 5. The average was 3.64 for the gamification plugin and 3.78 for the social networking site, indicating that students' attitudes towards both experiences was positive. The highest rated items for the social networking site were items 1, 4 and 5, suggesting that contents were properly designed in an easy-to-use and useful manner. Results are the opposite for the gamification plugin where items 1, 4 and 5 were among the lowest rated elements while items 6 and 7 were the highest scored items, indicating that the amount of activities and time for them was adequate according to students' perception. Also, in contrast, items 6 and 7 were among the lowest rated items for the social networking tool. Item 8 got a low score in both cases, suggesting low involvement of students with both tools and especially with the social network.

Table 5. Attitudinal survey and results for both experimental groups (N=45 for the gamified group and N=97 for the social networking group).

Question	Group	N	Mean	Std. Err.	Std. Dev.
#1 Content was efficiently presented	Gamif.	45	3.64	.13	.88
	Social	97	4.18	.08	.83
#2 I learned about the course topic with the tool	Gamif.	45	3.76	.13	.86
	Social	97	3.82	.11	1.09
#3 I enjoyed the experience	Gamif.	45	3.50	.15	.99
	Social	97	3.69	.09	.94
#4 The tool was easy to use	Gamif.	45	3.24	.17	1.15
	Social	97	4.04	.10	.99
#5 The functions and practical activities were useful	Gamif.	45	3.56	.15	.99
	Social	97	4.05	.09	.92
#6 There was a sufficient number of stuff and activities	Gamif.	45	3.91	.13	.90
	Social	97	3.68	.10	1.06
#7 Time to complete the activities was enough	Gamif.	45	3.98	.15	.99
	Social	97	3.67	.09	.92
#8 I was involved	Gamif.	43	3.40	.13	.85
	Social	96	3.02	.11	1.10
#9 I want to learn more about the course topic	Gamif.	44	3.64	.15	.99
	Social	97	3.66	.09	.98
#10 Learning experience was worthwhile	Gamif.	45	3.76	.15	.98
	Social	97	3.98	.09	.90
Average	**Gamif.**	**-**	**3.64**	**-**	**-**
	Social	**-**	**3.78**	**-**	**-**

Answer variability is low since the overall standard deviation is .96, which represents approximately 1/4 of the mean, so answers could be considered homogeneous. An item analysis was also run to measure the internal consistency of the instrument. It returned a Cronbach's alpha score of .858, which is higher than the commonly accepted benchmark of .7, suggesting that all the items in the questionnaire measured the same construct.

The attitudinal survey was also used to ask students that did not use the instruments for the reasons that prevented them from participating. 57 students of the gamified group and 75 students of the social networking group acknowledged not having used the instruments. Results are summarized in Table 6. Students could give more than one reason or no reason at all. Time availability was the most frequent reason given by students of both groups. Not knowing the existence of the social networking site was the second most given reason in the social networking group, while technical problems was the second cause of the students in the gamified group not using the tool. The reason given less frequently was the difficulty to use or understand the system. Under "other reasons," students were allowed to write their reasons. Examples of answers provided by students of the gamified group include "too many students" and "I don't like competition." Those of students in the social networking group include "participation was

not promoted and announced sufficiently in the lectures" and "too many digital versions in which I can participate, of the different courses."

Table 6. Reasons given by students for not using the instruments (N=57 for the gamified group and N=75 for the social networking group). Students could select more than one reason or no reason.

Answer	Group	Frequency
I did not know about it	Gamif.	9
	Social	20
I was not interested	Gamif.	6
	Social	9
I did not have time	Gamif.	34
	Social	34
I found technical problems	Gamif.	13
	Social	14
The system was difficult to use/understand	Gamif.	3
	Social	1
Other reasons	Gamif.	18
	Social	18

4. CONCLUSIONS

This experiment aimed to compare two educational approaches, gamification and social networking, in terms of students' achievement, participation and perception. Results suggest that the proposed instruments improve students' performance on practical assignments related to skill acquisition. Average performance improved in each experimental group even with low participation rates affecting the whole group significantly. Temporal evolution suggests that for initial assignments, social networking was a better option. But, over the duration of the course, results were similar for both instruments with active participants getting slightly better scores than non-participants. When it came to written examinations that primarily assessed knowledge, results suggested that traditional e-learning approaches were the best option and provided a good basis to get the best results in terms of academic achievement. We think that both experimental instruments overemphasized skill acquisition, resulting in poorer scores on knowledge acquisition. Comparing both experimental instruments in terms of academic achievement for knowledge acquisition, participants in social networking got better results, which were even better for active participants.

As for participation scores, the social networking group of students that actively participated got the best results. This may be logical since social networking promotes collaboration and participation. This group was followed by the control group. This

suggests that traditional e-learning tools coupled with an appropriate method also foster participation. Students of the gamified group got lower participation scores, suggesting that this approach may emphasize competition over collaboration and sharing, thus reducing participation of students.

The attitude of students was positive. Their perceptions of the social networking site indicate that the content was useful and efficiently presented, and that the tool was easy to use. On the other hand, they found that there was an insufficient number of available materials and that there was not enough time to complete the exercises. Perceptions of the gamified group contrasted with those of the social networking group. A major concern of the gamified group was the ease of use, but they were satisfied with the number of activities and the time allowed to complete them. Both groups acknowledged having a low involvement rate, especially the social networking group. This is confirmed by the graph of the social network.

Low participation rates are a major concern in our opinion. Lecturers established benchmarks of what represented a reasonable participation threshold, which was roughly a 20% of active engagement with the course materials and/or completion of the optional activities. Under this premise, we found that 59 out of 174 (38%) students actively participated on the social networking site and 27 out of 112 (24%) students actively engaged with the gamification plugin. These results as well as the participation scores suggest that designing a gamification approach that promotes achievements, collections and competitions does not necessarily stimulate participation. Social networking seems more promising in this respect, but the bottom line is, in our opinion, that a careful instructional design driven by clear objectives is essential for a meaningful integration of gamification in e-learning approaches. Exactly in the same way that the motto “built it and they will come and learn” proves to be wrong for e-learning (Zemsky & Massy, 2004), similar dictums like “socialize it and they will participate” or “gamify it and they will be motivated” seem to be equally flawed simply because they are ignoring the necessity of an underlying sound pedagogy.

The main limitation of our experiment is that it took place in a confined, limited environment that may not permit generalization. Generalization may also be questionable if we take into account that the functionality offered by the instruments was also limited, especially in the case of the gamification plugin where emphasis was put on achievement, collection and competition. As other authors have pointed out, the effects

of gamification are greatly dependent on the context in which it is implemented and on its users (Hamari et al., 2014). A second limitation is the influence that external conditions may have on results. Participants were not randomly assigned to conditions, but rather a quasi-experimental design was used in which participants were assigned to conditions based on existing activity groups for the course. Therefore, groups were not uniformly similar in age, major or subject matter, and geographical location. The influence of these variables on results cannot be assessed in the current study and additional experiments are needed.

Finally, considering future work, it is not necessary to decide between one approach and the other, but rather important that researchers and instructional designers strive to harness the potential of both. Long-term motivational benefits of gamification can be coupled with the collaborative and participative capabilities offered by social networks. In the authors' opinion, the social gamification of e-learning may represent a step forward in the realization of participative, motivating, engaging and meaningful learning experiences. Further integration of game elements like narratives and immersive 3D virtual environments are also challenging research lines (Gutiérrez et al., 2008, Berns et al., 2013).

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3.3. Resumen de los resultados del artículo 2

En este capítulo hemos mostrado una comparativa entre los efectos de redes sociales, gamificación y plataformas e-learning tradicionales en la participación y en el rendimiento académico de los alumnos en una formación semipresencial. Los resultados de esta comparativa muestran que el uso de gamificación o de redes sociales como herramientas complementarias a una plataforma e-learning tradicional no tiene por qué redundar necesariamente en mejores tasas de participación que las conseguidas exclusivamente con herramientas e-learning tradicionales. Atendiendo exclusivamente al uso de las herramientas experimentales, estos resultados también sugieren que las redes sociales fomentan más la participación de los alumnos que la gamificación, especialmente entre aquellos que más involucrados están en el uso de cada herramienta. En cuanto al rendimiento académico, los efectos observados en ambos casos son muy similares y poco significativos, lo que sugiere que, independientemente del tipo de herramienta, sigue siendo necesario un enfoque adecuado en su diseño y en el de sus contenidos para que tengan un impacto significativo. En concreto, con el diseño utilizado en nuestros experimentos y al igual que en experimentos previos con gamificación, ambos tipos de herramienta han mostrado tener un cierto efecto positivo en la adquisición de habilidades prácticas, pero negativo en el aprendizaje de conceptos teóricos.

Tras estudiar los efectos de la gamificación y las redes sociales de forma independiente, procedemos a abordar en el próximo capítulo el estudio de una herramienta de gamificación social que combina los mecanismos de motivación propios de ambos tipos de herramienta, buscando aprovechar los puntos fuertes cada una. En este nuevo estudio cambiamos sin embargo de objetivo, pasando de analizar su efecto sobre el rendimiento académico, a estudiar otro de los posibles beneficios derivados del uso de este tipo de instrumentos, el de predecir el progreso académico de los alumnos en base a su actividad.

Capítulo 4

Estudio de la relación entre la estructura de la red social y el aprendizaje en una experiencia de gamificación social

4.1. Contribución del artículo 3

La gamificación social aplicada al e-learning puede entenderse como la combinación e integración de los mecanismos de motivación propios de la gamificación con las funciones de comunicación y socialización de las redes sociales para fomentar interacciones entre alumnos que resulten productivas a nivel académico. Aunque este es el principal beneficio que se le presupone a la gamificación social, no es el único. El hecho de tener una infraestructura de red social también permite aprovechar las ventajas ya conocidas de este tipo de instrumento. Una de ellas es la posibilidad de analizar las métricas de interconexión entre usuarios para obtener información útil sobre ellos, utilizando para ello la técnica conocida como SNA (Social Network Analysis).

El uso de SNA sobre la red social que se genera en el transcurso de un programa formativo donde se incluyan herramientas de gamificación social puede arrojar mucha información sobre la forma en la que los alumnos interactúan entre sí. Por ejemplo, es posible averiguar si la red social generada se asemeja a las redes sociales que surgen en otros contextos de actividad humana, dando muestras, en caso de ser así, de que el instrumento es significativo para fomentar la interacción entre alumnos. Sin embargo, parte de la información obtenida mediante SNA podría no ser de utilidad para el profesor o para la institución académica, al no relacionarse de forma clara con aspectos académicos como la motivación o el rendimiento. Para hacer del SNA una herramienta útil en el ámbito educativo resulta necesario encontrar relaciones entre las distintas métricas que se obtienen de la red social y otros parámetros de mayor interés académico. La existencia de tal relación arrojaría luz sobre los efectos de la gamificación social en la educación, y mostraría la utilidad del SNA en contextos educativos como fuente adicional de información sobre los alumnos.

En este capítulo estudiamos esta idea, analizando en primer lugar la estructura de la red que se genera en una plataforma de gamificación social utilizada en una asignatura

universitaria semipresencial. Mediante la estructura comprobamos si esta red se asemeja a otras redes sociales habituales en distintos contextos de actividad humana. Seguidamente, a partir de este análisis, continuamos con el estudio de las relaciones que se pueden establecer entre las distintas métricas de la red social y el rendimiento académico de los alumnos.

4.2. Artículo 3

A continuación se incluye el artículo 3, "Social network analysis of a gamified e-learning course: Small-world phenomenon and network metrics as predictors of academic performance", en su versión pre-print.

Preprint Version of the final Manuscript: de-Marcos L., García-López E., García-Cabot A., Medina-Merodio J.A., Domínguez A., Martínez-Herráiz J.J., Diez-Folledo T., Social network analysis of a gamified e-learning course: Small-world phenomenon and network metrics as predictors of academic performance, In Computers in Human Behavior, Volume 60, 2016, Pages 312-321, ISSN 0747-5632, https://doi.org/10.1016/j.chb.2016.02.052

Social network analysis of a gamified e-learning course: Small-world phenomenon and network metrics as predictors of academic performance

Abstract: Social networks and gamification are having an important and growing role in education. Social networks provide unknown communication and connection possibilities while games have the potential to engage students. This paper analyzes the structure of the social network resulting from a gamified social undergraduate course as well as the influence that student's position has on learning achievement. In a semester long experiment, a social networking site was delivered to students providing gamified activities and enabling social interaction and collaboration. Social network analysis was used to build the network graph and to compute four measures of the overall network and nine measures for each participant. Individual measures were then assessed as predictors of students' achievement using three different methods: correlation, principal component analysis and multiple linear regression. The resulting social network has 167 actors and 2505 links, and it can be characterized as a small-world. All analyses agreed on the potential of structural metrics as predictors of learning achievement but they differ in the measures considered as significant. A moderate correlation was found between most centrality measures and learning achievement.

Keywords: e-learning, social network, gamification, social network analysis (SNA), small-world

1. INTRODUCTION

A social network is a structure made up of a set of actors and connections between them. Social networks are pervasive in many aspects of life and nature but most connections in social networks of the real world remain hidden. With the information age, social networking sites like Facebook, Twitter, Flickr and others have made these connections explicit, visible and exploitable. Information about the network can now be gathered and analyzed. The network can be represented as a graph in which nodes are the actors of the network and the arrows represent relationships between actors. Social network analysis (SNA) aims to find patterns of connections among actors analyzing the structure of the network in order to discover the effects of such patterns on people and organizations (Martínez, Dimitriadis, Rubia, Gómez, & de la Fuente, 2003). Teachers and educational researchers have increasingly turned their attention to educational networking, which is the use of social networks for educational purposes, as a method to create better and more efficient learning experiences. Educational networking provides the means for collaborating and sharing information towards solving problems and building knowledge, and SNA then provides the tools to analyze the structure of the network offering additional insights.

Videogames offer interactive feedback-driven experiences in immersive worlds with rich narratives that create compelling stories. Furthermore, good videogames are learning tools that challenge gamers with a seamless set of short term goals enabling them to master skills in a motivating and engaging environment (Gee, 2007); so educators are also trying to harness the potential of videogames in education. Game-based learning has taken several forms: educational games, serious games and gamification. Educational games are explicitly designed for learning. Serious gaming is a broader area which is focused on building games for a primary purpose other than pure entertainment, which can be educational or not. Gamification is a wider term that encompasses the use of game-design techniques in non-game contexts to engage people and motivate action (Kapp, 2012). While there is significant evidence of the positive impact of computer games and serious games on a wide range of educational outcomes (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012), gamification is a relatively new field with potential that teachers and researchers are just beginning to explore. Gamification provides a set of tools that can motivate action and make learning experiences more engaging. With challenges, levels, points, badges and leaderboards, among others, students can have timely feedback, meaningful rewards and social recognition.

Bringing together social networking and gamification is then a promising approach to create engaging and collaborative learning experiences. But the question that remains open, beyond the effectiveness of these approaches, is whether they create meaningful learning scenarios. Significant network effects have been reported in business, education and e-learning settings (Baldwin, Bedell, & Johnson, 1997; Cho, Gay, Davidson, & Ingraffea, 2007; Sparrowe, Liden, Wayne, & Kraimer, 2001). This study sets out to test whether similar effects can also be found in social e-learning settings driven by gamification, because competition and external rewarding make them considerably different from traditional classrooms and collaborative e-learning. In particular we want to examine whether the underlying social network of a gamified undergraduate course is a small-world. Small-worlds are a natural emergent structure in human activities and organizations that was reported in larger social networks like Flickr, YouTube, LiveJournal, and Orkut (Mislove, Marcon, Gummadi, Druschel, & Bhattacharjee, 2007). We also analyze the influence of the network on individual students as measured by the impact that positioning may have on learning achievement. The rest of the paper is structured as follows: Section 2 presents

previous research. Section 3 presents the experimental design, the instrument and the measures. Section 4 presents results. Discussion follows in section 5. Finally, section 6 summarizes conclusions and outlines future research.

2. PRIOR RESEARCH

Our study focuses on the social gamification of e-learning to analyze the effects of gamification in the resulting structure of the network and it also examines how the position of each particular learner impacts in her learning performance. It builds on previous work about gamification and social networks in education. This study uses gamification as an instrumental overly layer to promote participation in a social networking tool so existing literature on gamification in education is firstly examined. Education is the most common context of use of gamification (Hamari, Koivisto, & Sarsa, 2014) although contrasting evidence can be found about its effectiveness. Previous research suggests that learners anticipate higher value from gamified initiatives (Landers & Armstrong, in press) and also that they like it (Attali & Arieli-Attali, 2015). Gamification also improves productivity and participation (Denny, 2013; Halan, Rossen, Cendan, & Lok, 2010; Li, Grossman, & Fitzmaurice, 2012) although no effects, positive or negative, have been found in duration (Halan, et al., 2010), quantity (Denny, 2013) or quality (Li, et al., 2012) of contributions by students. Positive influence on the quality of learning artifacts produced by students has also been reported (Hew, Huang, Chu, & Chiu, 2016). Impact in motivation is contradicting in educational (Hakulinen, Auvinen, & Korhonen, 2013; Hanus & Fox, 2015; Landers & Landers, 2014) as well as in non-educational contexts (Mekler, Brühlmann, Tuch, & Opwis, in press). Providing that gamification aims to drive motivation resulting in better learning outcomes, such results can ultimately question its effectiveness for educational purposes. In terms of learning performance, contrasting evidence has also been reported (Boticki, Baksa, Seow, & Looi, 2015; Denny, 2013). Several studies examine different reasons that may account for such contradicting results like the kind of evaluation item (Domínguez et al., 2013), the kind of learning outcome assessed (Denny, 2013) or the kind of knowledge that learning actions convey (de-Marcos, Domínguez, Saenz-de-Navarrete, & Pagés, 2014; de-Marcos, Garcia-Lopez, & Garcia-Cabot, 2016), suggesting that the effectiveness of gamification is highly contextual.

Previous research on gamification mostly points to the positive attitude of students stressing its potential in education but also suggesting that more research is required to determine the specific circumstances under which gamification yields measurable

learning benefits. Contrastingly, literature on the utility and effectiveness of social networks in education mostly reports positive learning outcomes suggesting that a significant potential lies in the integration of both approaches (gamification and social networking). We now review the literature on the effectiveness of social networking in education. A social network is a structure that represents a set of actors and the connections among them. Computers and information systems are not necessary to support or use social networks and indeed the positive effects of non-computer-supported networks is reported in education (Kadry & Fadl, 2012; Oskouei, 2010). Internet-based information systems make explicit the connections of social networks and facilitate social media that allows participants to create, share and exchange content. The effectiveness of social media in education has also been widely studied. The educational use of paradigmatic social media tools like Facebook results in positive effects on students' attitude, communication, collaboration, interaction and learning performance (Despotovic-Zrakic, Labus, & Milic, 2011). Networking tools, like the Elgg blogging and peer-rating social system, also return a positive relation between usage and learning achievement (Thoms, 2011). Self-reported evidence also suggests that students that prefer sharing information in a social network outperform students that prioritize knowledge creation, acquisition and application (de-Jorge-Moreno, 2012). Specific educational networking tools, like Ning, improve collaboration (Brady, Holcomb, & Smith, 2010) and significantly influence students' motivation, retention, engagement, individual creativity and personal interaction (Hoffman, 2009). Previous studies also address other educational issues such as the quality of knowledge construction and the role of participants (Aviv, Erlich, Ravid, & Geva, 2003), the sense of community of students (Shen, Nuankhieo, Huang, Amelung, & Laffey, 2008), the perception of students about their own collaborative attitudes (Martínez, et al., 2003), and the evolution and differences observed in the structure of the network at different stages (Lee & Bonk, 2016).

Nevertheless, a recent literature review emphasizes that most of the existing research on the effectiveness of social media is based on self-reported data (Tess, 2013) questioning its empirical validity. Still, web based information systems also facilitate data acquisition, manipulation and analysis. Social network analysis can then be used to study the structure of the network and the influence of positioning on each participant. To our best knowledge there are a limited number of studies that analyze the structure of the social network in educational settings or that study the position of individual students in the network and its influence in learning outcomes. Previous

research suggests that the position in the network is positively related with learning performance in computer supported collaborative learning (Cho, et al., 2007; Maglajlic & Gütl, 2012). In terms of the structure of the network, network properties impact in social learning (Paredes & Chung, 2012) and creativity (Gaggioli, Mazzoni, Milani, & Riva, 2015); particularly density and decentralization are positively related with creativity. Our study follows this line of enquiry analyzing the structure of the network and the position of each participant in a more present technological context driven by a social gamificiation. Studies that bring together gamification and social networks are either not in the context of education (Thom, Millen, & DiMicco, 2012) or just present proposals and case scenarios with no empirical evaluation (Simões, Redondo, & Vilas, 2013).

This paper then sets out to study the relation between learning performance and students' positioning in the network using a locally controlled social networking e-learning system that provides a seamless integration of gamified educational content and social networking. In this way, we are able to gather data that reveals the structure of the network, and also to compute different metrics for each participant that can be used to feed models that predict the learning performance of students. Although there is previous research that evaluates how the various network positions are associated with performance in different e-learning settings, to our best knowledge, there is no research on such association in educational social networking settings driven by gamification features. We also study the overall structure of the network and analyze to which extend it resembles the structure of other social networks that are commonly found in human activities. Particularly we will examine whether the resulting social network of a gamified e-learning course is a small world. Our paper contributes to the current state of the art by (1) integrating gamification in a social networking context to analyze the structure of the resulting social network, (2) studying the relation between the position in the network and academic achievement in the same context, and by (3) combining gamification, social networking and SNA to pursue these goals.

3. EXPERIMENTAL DESIGN

3.1. Research questions

Our semester-long experiment aimed to explore the network structure of a social gamified course and the influence of the structural factors of the network in performance of students. We formulated the following questions concerning the network structure:

Q1.1: What is the network structure of a social gamified course?

Q1.2: To what extent does the structure resembles those of other social networks?

As for the relation between network structure and academic achievement, the following questions were formulated:

Q2.1: Can network metrics be used as predictors of performance?

Q2.2: Are prediction models coherent and representative?

3.2. Study site

The data for this study were collected from the undergraduate course 'Qualification for ICT users' which is 15-week course covering the basics of information and communication technology, and providing basic knowledge and skills of computing and office applications. Syllabus is based on the European Computer Driving License (ECDL) and the International Computer Driving License (ICDL) certification programmes[1], which are intended to become vendor independent de-facto standard certifications of digital literacy. The course has a blended learning approach. Students have 2 hours of lectures every week which are complemented with previous readings and additional activities that are delivered online using an e-learning system. Activities are introduced in the lectures but students have to complete them on their own. Textual descriptions in documents as well as sample solutions are delivered using the e-learning platform.

3.3 Instrument

The main instrument was a social gamification tool (fig. 1) designed to provide social networking features as well as sense of meaning, mastery and autonomy by delivering gamified activities coupled with a set of challenges. Eleven activities were gamified using a three-stage model. Activities were delivered on a weekly basis with a description, learning objectives and deliverables. Students had to complete each activity and submit deliverables to the system (stage 1). After submission students had to review the submission of another student (stage 2). Reviewing had to be done based on a rubric checklist of 5-8 items (fig 2. presents an example). Peer-review was used to reduce the workload of lecturers and to promote reflective learning in students. Finally, students could check the results of the review for their own submission (stage 3). Students could also resubmit their own activity if anything was missing or wrong, or they could eventually send a request for additional reviewing by the lecturers if they thought that their activity was unfairly reviewed. Gamified activities and social support

[1] ECDL Foundation. ECDL / ICDL programmes: http://www.ecdl.org/programmes/ecdl_icdl

provided a basis for the 28 challenges that completed the experimental instrument. Challenges were designed by instructional designers and lecturers based on completion of activities (e.g. 'Sysadmin' for completing all activities about operating systems), performing different tasks on the system (e.g. 'Avatar' for updating their profile information) and social interactions (e.g 'Popular' for having 20 friends). Students were awarded points for achieving challenges and for completing activities: submitting activities, reviewing activities of other students and receiving positive reviews to their own activities. Points had a twofold function. Firstly, they were used to implement a leaderboard where students could compare their performance with other students (competition). And secondly, points provided a virtual currency that students could exchange in the virtual shop (fig. 3). Students could buy extra points towards their final score (maximum 5% of the final score) and different personalization features.

Fig. 1. Gamification tool

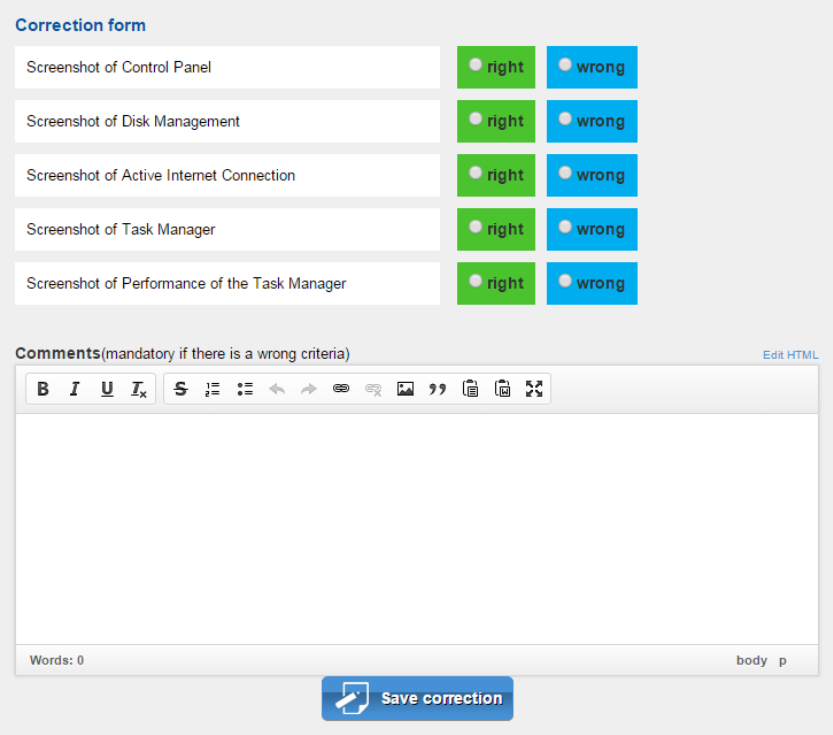

Fig. 2. Review form of an activity

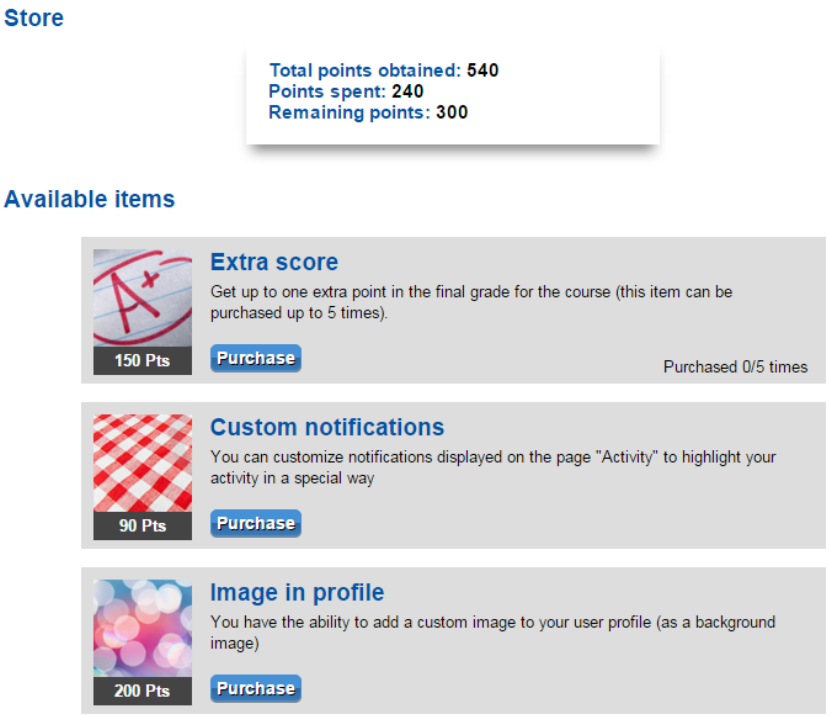

Fig. 3. Virtual shop

Gamification features were built over the Elgg[2] social networking engine which was also used to provide the following social functionalities and contents:

[2] Elgg - Open Source Social Networking Engine: http://elgg.org/

- Dashboard that showed recent activity in the platform.
- Videos presenting how to perform the basic operations with the computer tools (e.g. Applying styles and creating tables of contents in the word processor) and additional videos providing a step-by-step solution to each activity of the course. Students could also submit any video that they found or produced.
- Blogging. Both students and lecturers had blogging options enabling them to post entries controlling their visibility (all participants, just followers or private).
- Followers. Participants could follow other participants and monitor their activities on the site.
- Questions and answers (Q&A) where students could submit questions for other participants to answer. All participants could rate answers.
- Twitting. A built-in twitter-like system was included in the site enabling students to publish short comments at any moment.
- Commenting and liking. Students could comment any content on the social networking site and 'like' on them.

The tool was deployed on a web server and made available during the term. Only enrolled students were allowed to participate. All students were registered in the platform on first week of the course. Students only needed their credentials and a web browser to login. The home web page of the tool was the dashboard. A top menu with the following options was implemented and displayed: activity, blogs, questions, the wire and members. Under activity, the dashboard was presented. Under blogs and questions, students could access the blogging and Q&A tools previously described. 'The Wire' provided access to the build-in twitter tool. Under members, students could browse other participants, check their activities, communicate with or follow them. Gamification instruments were provided under the menu entry with the same name (fig. 1). Students could click on 'Tasks' to access to the list of gamified activities available, read their instructions, get the files and other supplementary materials to complete them, submit them, review the tasks submitted by other students (fig. 2) and check the reviews they got on their own tasks. Under 'Achievements' a list of all achievements with instructions of how to get each was presented. The leaderboard ranked students according to the total amount of points that they earned. Finally, the shop (fig. 3) allowed students to buy different items. Students could get a 5% of the final score (extrinsic motivator) and also two different personalization features that provided visibility and status in the platform by displaying their avatar and the messages of their

activities in the dashboard more prominently. Personalization tools could be configured after purchasing.

The social gamification tool aimed to create meaningful affordable experiences by providing a sense of meaning, mastery and autonomy (Deterding, Dixon, Khaled, & Nacke, 2011). Meaning was conveyed through personal goals represented by activities and challenges carefully aligned with the learning objectives. Each learner could also customize her learning experience deciding which tasks she wanted to complete thus providing autonomy. Finally, a careful scaffolding of activities accounted for mastery. Each topic was divided in 2-3 activities delivered in sequential levels of complexity. And each activity was divided in a set of tasks tied to a learning objective so that learning was structured as a set of subgoals contributing to a larger goal.

Peer-review and social networking provided a pro-social component enabling community building and collaboration. We also wanted to provide room for different player types as described in different models (most notably Bartle's (Bartle, 1996)) so the leaderboard was included to offer an opportunity for competition. The rewarding system was designed mostly to promote intrinsic rewards. Extrinsic rewarding systems can be problematic, even demotivating indeed, but they can also be the trigger towards internal motivation in which the activity becomes motivating in and by itself. Self-determination theory (Ryan & Deci, 2000) describes a kind of continuum between extrinsic motivation and intrinsic motivation in which external rewards can initially be used as a mean for germinal motivation. The virtual shop was then included as an external motivator allowing students to turn their work and contributions into a 5% of their final score. But to mitigate the possible demotivating effect of extrinsic rewarding additional elements were included in the shop. These items focused on personalization providing social visibility.

3.4. Methodology & measures

The instrument was delivered to a group of 161 first- and second-year undergraduate students majoring economics, business administration or life sciences. Experiment was run during the spring semester of 2013 when students interacted with the system by completing activities, getting challenges and collaborating through social networking. Lecturers monitored the activity and provided final scores of students while researchers collected and analyzed data about the usage of the social network. Gephi graph visualization tool was used to represent and analyze the social network of followers at

the end of the term. The Elgg social networking engine, used as the backbone for the social gamification system, provided means to export the network in different formats. Data was imported to the social networking software in GraphML format. The final network was represented as a directed graph in which nodes represent participants and edges represented followers. Different measures were gathered or computed for each participant including structural network metrics and learning performance. Overall network measures were also computed. A description of these measures follows.

Basic centrality measures computed for each participant were degree, closeness centrality, eccentricity, eigenvector centrality and betweenness centrality. *Degree* is the number of links of an individual to other members in the network. In a directed network we can distinguish between in-degree (incoming links) and out-degree (outgoing links) and in this case the degree of a given node is computed as the average of in-degree and out-degree. *Closeness centrality* is the average distance from an individual to all other members in the network. *Eccentricity* is the distance from an individual to the farthest member from her in the network. *Eigenvector centrality* is a measure of an individual importance on the network based on her connections. *Betweenness centrality* measures how often an individual appears in the shortest paths between other members in the network. While all other centrality measures are associated to access to network resources, betweenness centrality usually refers to the access to novel information and control benefits. Individuals with higher betweenness tend to connect multiple and otherwise unconnected groups thus having access to resources from different sides.

Link analysis algorithms provide additional measures of centrality for the members of a network. Hyperlink-Induced Topic Search (HITS) and PageRank were also included to cover as much alternatives as possible. HITS (Kleinberg, 1999) computes two separate values for each individual: hub and authority. *Hub* measures the quality of links of an individual. A good hub is usually linked to many other members. *Authority* measures how valuable the information of a given individual is. A good authority is usually linked by many different hubs. *PageRank* (Brin & Page, 1998) is another link analysis algorithm that ranks individuals according to how often a hypothetical user following the links will non-randomly reach the individual, thus quantifying the relative importance of an individual node within the network. The algorithm uses a damping factor *d* which determines the probability of the hypothetical user to follow a link of the current

individual or randomly jump to any other individual in the network (1-*d*). Damping factor is usually set to .85.

Clustering coefficient was our final individual measure. It indicates how individuals are embedded in their neighborhood. The average clustering coefficient gives an overall indication of the clustering in the network. It is the mean value of all individual coefficients (Watts & Strogatz, 1998). This coefficient, along with the average shortest path, can indicate a small-world effect. *Average path length* is the average graph-distance between all pairs of members. Average clustering coefficient and average path length are measures of the whole network. All other previous measures referred to individuals but overall measures are also interesting since they aggregate individual values providing an indication of the network structure. Other network measures considered in this study were diameter and graph density. The *diameter* is the longest graph distance between any two members in the network (i.e. how far apart are the two most distant members). Network *density* measures how close the network is to be complete. A complete graph has all possible edges and a density equal to 1.

Learning performance of students was measured using their final grades. Students' grades were computed for four individual assignments (70%) and a final examination score (30%). Final grades were normalized on a 0-100 scale (M=80.22, SD=9.68). Students could "buy" a 5% of the final score but this part of the score was not included in the final grade for this study because the final grade is more representative of learning performance if it only includes the results of evaluation items.

To address research questions Q1.1 and Q1.2 overall network metrics were computed and the small-world hypothesis was contrasted. To address questions Q2.1 and Q2.2 three different methods were used. Correlation was used to find associations among variables. Exploratory factor analysis was used to identity relationships among variables and to group them. Regression was used to predict student achievement in terms of network measures. Our approach was to try to get as much measures as possible to feed models and use them to find the best possible characterization of the network.

4. RESULTS

To address research questions Q1.1 and Q1.2 we examined the resulting social network and the overall network measures to characterize its structure. The final

network of participants at the end of the term was represented as a directed graph (fig. 4) of 167 nodes and 2505 edges returning a density of .09[3]. There was a central hub in the network representing a student with significantly more links than all other participants. Lecturers tended to occupy peripheral positions. Average degree was 15.36. Average out-degree was 15.42 meaning that each participant was following 15 other participants on average. Average in-degree was 15.29 so each participant also had about 15 followers on average. The network had a diameter of 5 and the average path length was 2.13. The average clustering coefficient was .401.

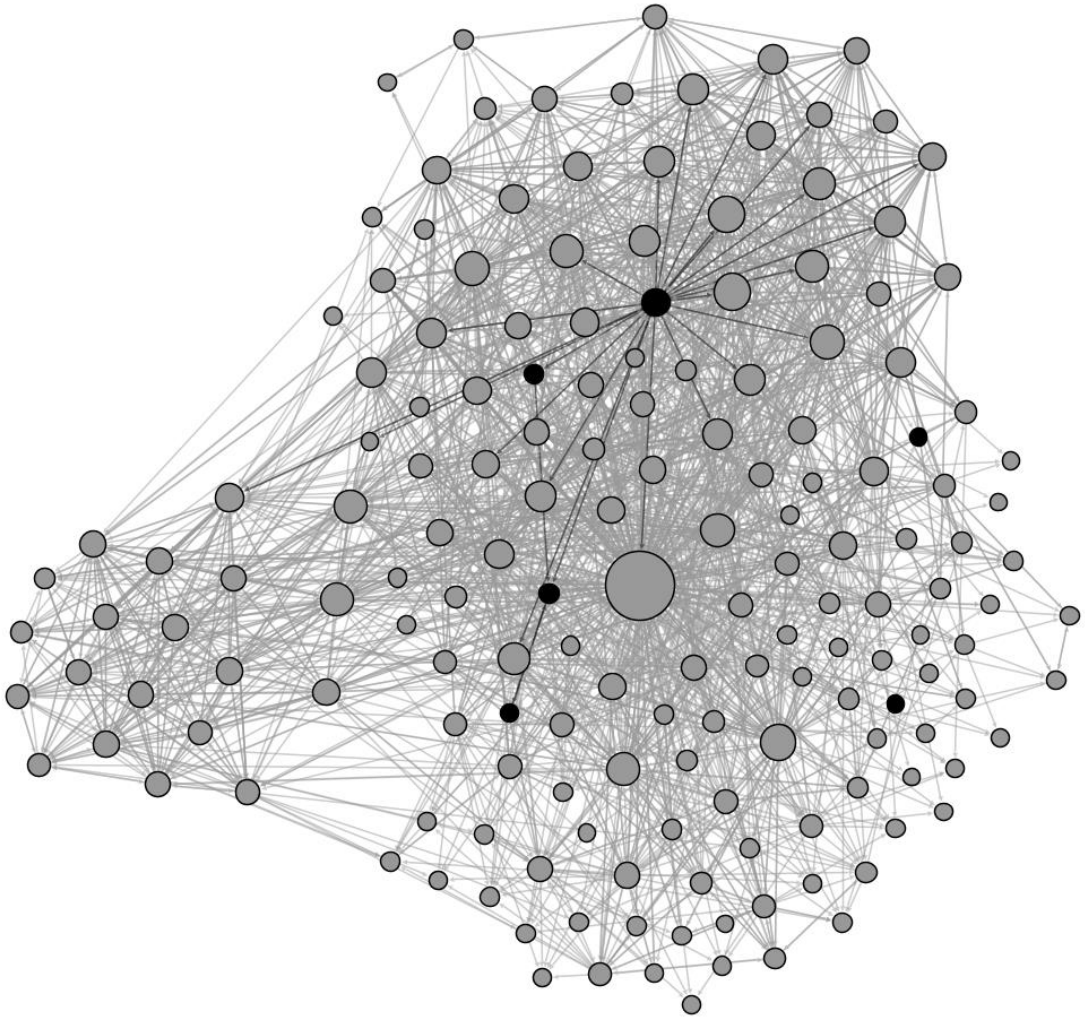

Fig. 4. Network structure as a directed graph of followers.
Grey nodes represent students and black nodes represent lecturers.
Edges represent followers. Node size represents degree

[3] The graph was created using Gephi graph visualization tool (http://gephi.org/) and applying a Force-Atlas2 layout.

A network can be considered a small-world, if the graph has approximately the same average path length than a random graph of the same size, and if the graph has a clustering coefficient that is significantly higher than the corresponding random graph (Kemper, 2009), roughly between three and five times larger (Mislove, et al., 2007). Ten random networks were generated to compute their average shortest path (M=1.95, SD=.015) and clustering coefficient (M=.089, SD=.002). Results (.401>.089, and 2.13 aprox. equal to 1.95) suggested that the resulting network could be characterized as a small-world. Small worlds also have other structural characteristics that were present in our network like low density, small diameter, and tendency to match in degree and out degree (Chakrabarti & Faloutsos, 2006; Mislove, et al., 2007; Nettleton, 2013; Robins, Pattison, & Woolcock, 2005).

As for research questions Q2.1 and Q2.2, correlation coefficients (table 1) suggested limited but significant relationship between students' achievement and degree. Measures obtained from link analysis algorithms (hub, authority and PageRank) were also positively but moderately correlated with students' achievement. Although some other measures were also correlated their effects seemed very small. Providing that correlation does not imply any casual dependence we also considered other methods.

Table 1. Correlations between social network measures and learning achievement

	1	2	3	4	5	6	7	8	9
1 Degree	-								
2 Closeness Centrality	.166*	-							
3 Eccentricity	.254*	.951*	-						
4 Eigenvector Centrality	.878*	.173*	.264*	-					
5 Betweenness Centrality	.715*	-.030	.019	.437*	-				
6 Hub	.935*	.334*	.412*	.946*	.525*	-			
7 Authority	.939*	.174*	.256*	.958*	.555*	.980*	-		
8 Pagerank	.916*	.240*	.311*	.920*	.581*	.956*	.961*	-	
9 Clustering coefficient	-.325*	-.043	-.093	-.151**	-.221*	-.238*	-.249*	-.216*	-
10 Final grade	.313*	.118	.071	.205*	.209*	.304*	.291*	.273*	-.170**

*** p < .05**
**** p < .1**

Factorial analysis was used to reduce the number of measures to a number of factors in order to try to provide a clearer interpretation of data. We conducted the analysis with all variables making no 'a priori' assumptions about the associations among variables. KMO measure of sampling adequacy returned .779 and Bartlett's test of sphericity returned 2063.29 (p<.001). Therefore data was adequate for performing the

analysis. We extracted three factors that accounted for 83.76 of the overall variance (table 2). The eigenvalue of the third component was close to but less than one. We decided to include it to increase the explanatory power of the analysis. The appropriateness of a two-factor solution was also checked, returning two variables (final and clustering coefficient) with communalities less than .2.

The first factor, accounting a 55.28% of the variance, included 6 variables (degree, eigenvector centrality, betweenness centrality, hub, authority and PageRank) that presented a high positive association. All measures related with link quantity and link quality were included in this first component. The second component represented an 18.66% of the overall variance and it included two variables (closeness centrality and eccentricity) highly correlated. Both were measures of centrality accounting for opposite magnitudes (distance to the center and distance to the farthest node). The third component accounted for a 9.82% of the variance and it included the final score and the clustering coefficient. This suggested a high association between learning achievement and individuals' embedment in their neighborhood. The component plot (fig. 5) provided a visual representation of the variables outlining the three factors.

Table 2. Rotated component matrix of the principal component analysis and varimax with Kaiser normalization.

	Component 1	Component 2	Component 3
Degree	**.937**	.050	.280
Closeness Centrality	.053	**.975**	.074
Eccentricity	.163	**.966**	.059
Eigenvector Centrality	**.949**	.121	.026
Betweenness Centrality	**.644**	-.192	.303
Hub	**.945**	.241	.169
Authority	**.967**	.097	.165
Pagerank	**.951**	.154	.143
Clustering coefficient	-.173	-.077	**-.730**
Final grade	.148	.043	**.737**
Eigenvalue	5.53	1.87	.98
% variance explained	55.28	18.66	9.82
Cumulative % of variance	55.28	73.94	83.76

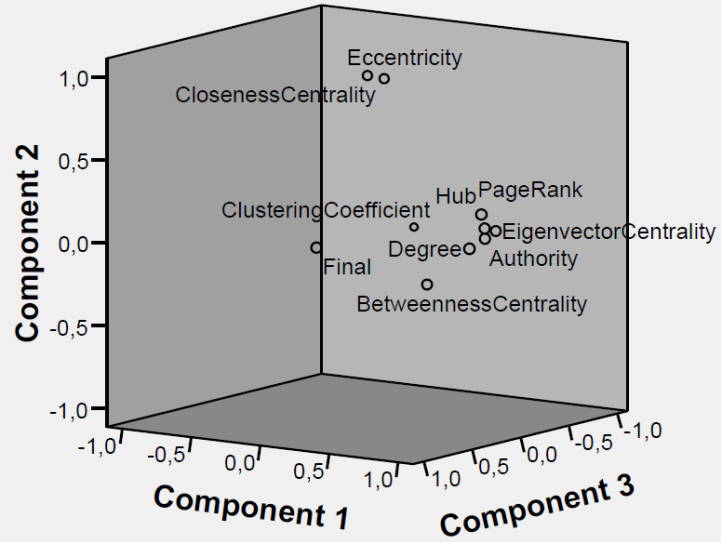

Fig. 5. Component plot in rotated space of the factorial analysis.

Table 3. Results of regression analysis predicting learning performance

	Unstandardized Coefficients		Standardized Coefficients		
	Beta	Std. Err.	Beta	t	p
(constant)	82.42	5.87	-	14.05	<.001
Degree	.12	.14	.361	.87	.387
Closeness Centrality	6.10	3.01	.553	2.03	.045
Eccentricity	-6.11	2.18	-.762	-2.84	.005
Eigenvector Centrality	-49.46	17.30	-.965	-2.86	.005
Betweenness Centrality	-.002	.002	-.167	-.98	.327
Hub	2805.73	1906.13	1.545	1.47	.144
Authority	-548.07	2031.89	-.257	-.27	.788
Pagerank	-515.41	815.11	-.199	-.63	.528
Clustering coefficient	-1.03	5.29	-.019	-.19	.846

Finally, we conducted a multiple linear regression to try to evaluate the predictive power of network measures. Results are presented in table 3. The linear model was significant ($F=4.02$, $p<.001$) but it did not fit the data particularly well ($R^2=.24$, Adjusted $R^2=.18$). Hub presented the largest standardized coefficient although it was not statistically significant. Closeness centrality presents a positive significant coefficient. Degree coefficient was not found to be significant. Eigenvector centrality and eccentricity also had high standardized coefficients which were statistically significant but negative. We may found this initially surprising in the case of eigenvector centrality as importance on the network should be positively associated with learning performance if all other centrality measures also are. As a possible limitation that can account for this incoherent result, we should consider collinearity among variables. As for the negative coefficient found for eccentricity, a negative relationship can be

presumed as individuals with high eccentricity occupy peripheral positions in the network.

5. DISCUSSION

Visiting back research questions, we can conclude that the social network structure of a gamified course resembles a small world (research questions 1.1 and 1.2) suggesting that this kind of approaches may be meaningful because the underlying structures created are similar to those found in the real world and other online networks. The small world hypothesis asserts that a small set of links can produce chains that connect two arbitrary and even distant members of the network. Small worlds have two other important features (Kleinberg, 2000): (1) The network is resilient and adapts to changes so that chains of connections are ubiquitous even in the event of temporal or permanent unavailability of members or links. (2) Individuals operating with local links can find global short chains very adeptly. Small worlds are found in different in business (Davis, Yoo, & Baker, 2003; Lundberg, 1975) and in many other human issues including educational settings (Stevenson, Davidson, Manev, & Walsh, 1997). Common sense and intuition suggest that online learning communities should have a similar structure and our analysis validated this assumption in a gamified course in which rewards that promote learning indirectly influence network creation.

As for research questions 2.1 and 2.2 we observed that several metrics can be used as predictors but that the representativity of the models is limited and therefore their predictive power is poor. Although some small internal incoherencies are observed in the three models, the most relevant outcome is how the models differ. We found a positive correlation between students' performance and six of the metrics employed (degree, eigenvector centrality, betweenness centrality, hub, authority and PageRank). There is also a limited but negative correlation between performance and clustering coefficient ($r=-.17$, $p<.1$). The principal component analysis also returns this negative relation (loading factors -.730 and .737). This suggest that the embedment in the local neighborhood as measured by the clustering coefficient ultimately results in a negative learning outcome and that global connections are also important in learning environments. The regression model suggests that three variables (closeness centrality, eccentricity and eigenvector centrality) have a significant coefficient. So each model found a different set of significant variables and therefore all variables can be potentially useful. Although we also have to point that measures of link analysis algorithms (hub, authority and PageRank) only resulted significant in the correlation

analysis. Furthermore, principal component analysis reveals that these measures are in the same principal component in which most centrality measures also are. This suggests that centrality measures have more predictive power than measures obtained from link analysis algorithms, and somehow validates previous studies that did not consider them but rather focused mostly on centrality metrics (Baldwin, et al., 1997; Sparrowe, et al., 2001). Results also show that centrality measures have more impact on learning performance than brokerage position as measured by betweenness. This suggests that the number of contacts and the opportunity to get information from them is more important than control over strategic positions that may provide better and faster access to novel information. Cho et. al (Cho, et al., 2007) reported similar results suggesting that online educational settings are not competitive but rather of a more cooperative kind and, therefore, control over strategic information does not influence outcomes as it does in business or other organizations where resources may be limited.

As possible limitations of our study we point the contradicting results of factor analysis and regression. While factor analysis suggests a relation between the final grade and clustering coefficient, results from regression suggest that only two centrality measures (eccentricity and eigenvector centrality) are significant but both have negative coefficients In the case of regression, multicollinearity is also a potential limitation. Two or more predictors may be highly correlated resulting in coefficient estimates not accurate, although the predictive power of the model as a whole is not affected. Our study is also restricted to a snapshot at the end of the term. Initial situation is not studied for any of the variables considered. An initial analysis of the social network and pre-test data about student proficiency may provide additional insights about the evolution of the network and of students' learning. Similarly data is not contrasted with any control group to examine whether this approach provides any benefits over traditional methods in terms of learning performance. Finally, the sample size (N=167) and the specificity of the experimental setting (undergraduate course) may prevent generalization. Particularly, we have to mention that a full characterization of a network of a small-world requires checking if the degree distribution follows a power law. As it has been noted by Chakrabarti and Faloutsos, power laws seem to be absent in almost all social network literature and this could be, in part, because power laws can only be observed reliably in very large datasets (Chakrabarti & Faloutsos, 2006).

6. CONCLUSIONS

In this study we have designed a social gamification learning environment that motivates participation and learning in an undergraduate course. Our aim was to gather information about the underlying social network to study its structure and the influence of student's position in learning performance. The resulting network had 167 participants and 2505 links and SNA was used to analyze it. Four metrics of the overall network were computed and results suggest that the network of followers is a small world. This is a resilient structure found in many other different human and natural environments which give participants access to the whole network through chains of a few locally operated links. SNA was also used to compute nine metrics for each participant in order to predict learning performance in terms of student's position in the network. Three methods were used and they returned different results. Correlation results suggested a moderate positive relation between six of the metrics and learning performance. Principal component analysis suggested that there is a negative connection between learning performance and the degree of student's embedment in her local subnetwork as measured by the clustering coefficient. Correlation results also return a negative limited connection between these two variables suggesting the global connections are also important for learning achievement. Finally, a multiple regression model was fed with all individual metrics as predictors and learning achievement as response variable. It found three significant centrality measures (closeness, eccentricity and eigenvector centrality) although the model shows a limited representativity and seems to be biased by collinearity problems.

Implications of our work are as follows: (1) Social gamification tools driven by motivational affordances promote the creation of meaningful learning communities in terms of the overall structure of the network. (2) Student's position in the network seems to influence learning performance, although results of the three methods used were contradictory when pointing to the influencing measures. This suggests that further work is required to build more representative models. (3) From a methodological and technical perspective, we have the tools that facilitate data acquisition and data analysis, and therefore that enable to discover the details of the underlying networks in e-learning settings. Such implications initially raise awareness about the importance of social networks but also offer additional applications and value to different stakeholders: students, teachers, instructional designers, managers, administrators and policy makers. Our findings suggest that position in the network influences learning performance so learners would be informed about the benefits of

integration and meaningful participation in learning communities. Teachers and instructional designers would promote participation by enabling mechanisms that address the social and ludic needs of students. Managers and administrators could learn and be informed about the behavior of students in communities to scrutinize them but also to examine the overall structure of the network which provides relevant insights about the effectiveness of learning actions. They could also provide tools to teachers and instructional designers that capture and facilitate data about the underlying network. Reporting tools could be particularly useful if they provide individualized information that teachers can use to assess students and provide formative feedback. Global information of the network can also be used to evaluate the structure and patterns of the learning community during the learning action to implement corrective actions if necessary or, when finalized, to analyze its effectiveness in educational terms. Finally, policy makers may formulate guidelines that stress the role of learning communities and of the means to enable, promote and use them efficiently.

As future work, firstly we suggest trying new approaches to find more representative models. Data mining may provide more accurate descriptions and also address multicollinearity problems found here. Particularly, Educational Data Mining is a research area that has produced important results (Romero & Ventura, 2010) that can be explored. Secondly, we may investigate the initial structure of the social network as well as the initial levels of knowledge of students in order to analyze the real benefits that this kind of tools and approaches can provide in terms of learning as well as to study the evolution of both, learning and social structure. Thirdly, we may consider additional measures. As for the social structure, community detection algorithms can identify a set of modularity classes to which each individual belongs. Such information is categorical so models should be able to address it. Furthermore, our work has only considered structural features. Other studies have shown that psychological measures like communication style or learning style account for a considerable level of representativity (Cho, et al., 2007) so future models should also include these measures. Self-reported measures like network exposure, social influence, reciprocal benefit and recognition have also been addressed as influential aspects for the perceived benefits of gamification (Koivisto & Hamari, 2014) so they can also be studied in relation to other network metrics and learning performance. Finally, the gamification instrument can be further extended. For instance and according to game theorists, a game needs a story to provide a complete sense of meaning (Deterding, et

al., 2011). Recent evidence in GBL also suggests that story-based games are more useful for attracting and engaging participants (Prestopnik & Tang, 2015). Addressing narrative in gamified learning experiences is, in authors' opinion, one of the major challenges ahead.

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4.3. Resumen de los resultados del artículo 3

En este capítulo hemos mostrado que a través de gamificación social los alumnos generan redes sociales que podrían ser significativas para su aprendizaje al tener características de redes de mundo pequeño, similares a las que se crean naturalmente en otros contextos de actividad humana. Además, el estudio muestra que estas redes pueden ser analizadas mediante SNA para obtener información de utilidad para los distintos grupos de interés involucrados en el proceso formativo. En particular, los resultados del estudio sugieren que determinadas métricas de la red social relacionadas con la centralidad de los nodos tendrían relación con el rendimiento académico de los alumnos. Sin embargo, cada uno de los tres métodos utilizados para analizar la relación entre métricas de la red y el rendimiento académico devuelve un conjunto de métricas relevantes distintas. Es por tanto necesario continuar investigando sobre la materia para poder validar y generalizar los resultados obtenidos, así como para obtener modelos más significativos. En general, consideramos que este campo de investigación, poco explorado por el momento, podría resultar especialmente relevante en determinados contextos educativos modernos, como la formación completamente online o los MOOC, donde resultaría difícil obtener información sobre los alumnos mediante métodos tradicionales.

A lo largo de los tres últimos capítulos hemos mostrado las aportaciones y el impacto de los artículos presentados en esta tesis. En el próximo capítulo analizaremos y discutiremos en mayor profundidad los distintos resultados obtenidos a partir de estos trabajos.

Capítulo 5

Resultados y discusión

En los capítulos anteriores se han mostrado los artículos de investigación que componen esta tesis. A continuación resumiremos los resultados de cada uno de ellos y los discutiremos en relación a las preguntas de investigación planteadas.

5.1. Artículo 1 - Efectos de la gamificación en el rendimiento académico

En el primer artículo se presenta un experimento en el que un grupo de alumnos realiza un curso universitario semipresencial a través de una plataforma de e-learning gamificada, comparándolo con otro grupo que realiza el mismo curso a través de una plataforma e-learning tradicional. El objetivo de este experimento es evaluar el impacto del uso de gamificación en el rendimiento académico de los alumnos, analizando y comparando las calificaciones de ambos grupos a lo largo del curso. Adicionalmente también se recopilan datos de participación, así como datos cualitativos basados en cuestionarios realizados a los alumnos.

El curso en el que se basa el experimento es "Capacitación en el uso de las TIC", basado en el temario oficial de la certificación ECDL (European Computer Driving License). A través de la plataforma e-learning se ofrece a los alumnos una serie de actividades y ejercicios recomendados para mejorar su habilidad práctica y reforzar los conocimientos necesarios para la superación del curso y de la certificación. En el grupo experimental los alumnos tienen a su disposición versiones gamificadas de estas actividades, así como versiones tradicionales en PDF, pudiendo elegir y combinar qué actividades realizan en cada modalidad. La plataforma gamificada también incluye varios mecanismos de motivación, como puntos, medallas y rankings, donde los alumnos progresan al usar la plataforma y al enviar capturas de pantalla de las actividades realizadas para su evaluación por parte de los profesores. Al grupo de control, por el contrario, solo se les ofrecen las actividades tradicionales en PDF y no cuentan con los mecanismos de motivación de la versión gamificada.

Todos los alumnos involucrados en el experimento, en ambos grupos, se sometieron a seis pruebas distintas, cinco de carácter práctico y una de carácter teórico, con su correspondiente calificación. Además, cada alumno recibió una calificación adicional en concepto de participación, calculada en base a sus intervenciones en las actividades presenciales y

online. Todas estas calificaciones son tenidas en cuenta para la calificación final de la asignatura. El análisis de estos datos muestra que el grupo experimental obtuvo en general mejores calificaciones en varias de las pruebas prácticas, mientras que, por el contrario, el grupo de control obtuvo mejores calificaciones en la prueba teórica y en el apartado de participación. Un análisis más profundo muestra que, de forma significativa, los alumnos con un alto nivel de uso del sistema gamificado (22 %) tienen mejor calificación final; al mismo tiempo que los alumnos con un bajo o nulo uso del sistema gamificado (78 %) tienen peores calificaciones tanto en las pruebas prácticas como en la teórica. En todo caso, en la calificación final estas diferencias quedan diluidas, no encontrándose diferencias significativas entre los grupos experimental y de control.

Por tanto, en relación a la pregunta de investigación planteada, PI1 ¿Qué efecto tiene la gamificación sobre el rendimiento académico de los alumnos?, los resultados expuestos sugieren que la gamificación no tiene un efecto muy significativo en el rendimiento académico de los alumnos. Sin embargo, esta afirmación puede matizarse, ya que, si profundizamos en los resultados, podemos observar un efecto positivo y significativo de la gamificación en la adquisición de competencias prácticas por parte de los alumnos que utilizaron activamente la plataforma. Por el contrario, este efecto parece ser negativo en relación al aprendizaje de conceptos teóricos. Suponemos que estos resultados se deben a que la plataforma gamificada estaba diseñada para fomentar la realización de actividades prácticas, lo que de alguna forma distrajo a los alumnos del aprendizaje de los conceptos teóricos. Si así fuese, podríamos concluir que, aunque la gamificación puede tener un efecto significativo en el proceso de aprendizaje del alumno, que este redunde en un mayor rendimiento académico dependería de que el diseño del instrumento gamificado sea adecuado para los objetivos de aprendizaje y los criterios de evaluación del curso.

En todo caso, en el análisis realizado en el párrafo anterior no se está atendiendo a los resultados de actividad de los alumnos. De los 127 estudiantes del grupo experimental que obtuvieron calificación, solo 58 decidieron registrarse en la versión gamificada, 45 consideraron haber participado en ella una vez finalizada, y de estos últimos sólo 23 pasaron el filtro establecido por los profesores habiendo completado un número significativo de actividades gamificadas. Aunque estos números dependen de una gran cantidad de factores, en última instancia muestran la existencia de un problema real: gran parte de los alumnos prefirieron a priori el enfoque e-learning tradicional; y de los que optaron por el enfoque gamificado, menos de la mitad se sintieron motivados como para utilizarlo de forma continuada en el tiempo. Este problema requiere de un análisis pormenorizado, ya que, en la práctica, tan bajas tasas de uso de la versión gamificada hacen que su potencial impacto en el rendimiento académico se diluya, quedando en cuestión la idoneidad del enfoque utilizado y sus supuestos beneficios. Para mantener el interés por la gamificación parece necesario entender el porqué de estos resultados y proponer soluciones con las que conseguir que resulte atractiva y motivadora para una mayoría de alumnos.

Gracias a las encuestas realizadas entre los alumnos y a las opiniones que estos proporcionaron por distintas vías, podemos arrojar algo de luz sobre las motivaciones detrás de estos datos. De entre los alumnos que decidieron no utilizar la plataforma y proporcionaron feedback al respecto (n=59), más de un 70 % adujeron no disponer de tiempo o de interés. Según las opiniones dadas, algunos prefirieron el enfoque de e-learning tradicional por comodidad, al estar habituados a él, así como por no saber las dificultades que encontrarían en la versión gamificada o, sencillamente, porque pensaron que la versión

gamificada les haría perder tiempo. En otra encuesta informal (n=91) solo un 32 % de los alumnos del grupo experimental consideró más motivadoras las actividades gamificadas, un número claramente inferior al 62 % que consideró más motivadoras las actividades tradicionales. Parece claro que, por si misma, la experiencia gamificada no resultó suficientemente atractiva para gran parte de los alumnos, y que, en varios casos, esto se debió al desconocimiento de las ventajas e inconvenientes que esta tendría para ellos. Pensamos que la solución a este problema pasa, por un lado, por proporcionar a los alumnos más información sobre las ventajas e inconvenientes del uso de un sistema e-learning gamificado, y por otro, por mejorar la funcionalidad y usabilidad de la herramienta. Por ejemplo, uno de los puntos con más potencial de mejora podría ser el sistema de corrección de actividades, que requería que los alumnos enviasen capturas de pantalla de sus prácticas (generándoles trabajo adicional) y donde las correcciones, hechas por los profesores, podían tardar varios días en llegar, perdiéndose la sensación de feedback inmediato (o, al menos, rápido), uno de los mecanismos de motivación más importantes de la gamificación.

Las opiniones vertidas por los alumnos también nos hacen ver que existen otros problemas, adicionales a los planteados hasta el momento, que podrían tener relación con las bajas tasas de participación. Resultan especialmente interesantes las opiniones de algunos alumnos que adujeron como motivos para no participar la falta de interés e incluso por el rechazo que les producía tener que competir contra sus compañeros en un ranking. Algún alumno llegó a argumentar que los rankings utilizados en la versión gamificada no le resultaban justos ni representativos del aprendizaje real. Sin embargo, una mayoría de los alumnos que sí utilizaron activamente la plataforma comentaron lo alentador que había sido para ellos poder competir con sus compañeros, y que, en comparación con las actividades tradicionales, el obtener puntos, trofeos y posiciones en el ranking les había resultado motivador y divertido. Algunos incluso comentaron que habían realizado las actividades en su versión tradicional y posteriormente las habían subido a la plataforma gamificada para obtener las recompensas pertinentes. Estas opiniones positivas también se vieron respaldadas por las encuestas de satisfacción realizadas a los alumnos que consideraron haber utilizado la plataforma, y que, en general, indicaron una buena actitud y motivación hacia la experiencia gamificada y hacia la herramienta. Como conclusión de estas dispares opiniones, podemos decir que el enfoque de gamificación competitiva, al menos en la forma básica en la que estaba planteado en el experimento, puede resultar muy motivador para algunos alumnos, pero no para una mayoría, a los que les resulta irrelevante o incluso desmotivador. Pensamos que la solución a este problema pasaría por hacer opcionales o por dar un papel secundario a los aspectos competitivos, enfocando en su lugar la gamificación en aspectos cooperativos y sociales. Esta es, en efecto, la línea con la que continuamos nuestra investigación. También se podría argumentar que quizás el enfoque utilizado podría haber funcionado mejor en entornos de aprendizaje muy competitivos, pero incluso en ese caso y vistos los resultados, nuestra opinión particular es que el sistema de rankings debería ser más elaborado para resultar realmente motivador, algo en lo que no hemos llegado a profundizar en nuestra investigación.

Un último aspecto que quizás afectó negativamente al impacto de la gamificación en el aprendizaje de los alumnos fue la percepción demasiado optimista de muchos de ellos sobre el nivel de uso que habían hecho de la plataforma. Hasta 45 alumnos consideraron haber participado en la experiencia gamificada. Estos alumnos rellenaron una encuesta de satisfacción de la que se extrae que, de media, consideraron haber completado alre-

dedor del 56 % del total de actividades que les ofrecía la herramienta. Sin embargo, los datos reales indican porcentajes de completitud mucho menores, de un 23 % atendiendo a quienes completaron al menos una actividad gamificada (58 alumnos), o de un 41 % en el mejor caso, si solo consideramos a los alumnos que pasaron el filtro de actividad mínima establecido por los profesores (27 alumnos que completaron 8 o más actividades gamificadas en al menos 3 módulos distintos). Aunque no están claros los motivos de esta visión tan optimista del nivel de uso de la herramienta, la diferencia entre la percepción de los alumnos y el progreso real que alcanzaron sugiere que la forma de representar su nivel de progreso al alumno requiere de mejoras, ya sea para que se ajuste con más precisión el progreso real o para que los alumnos lo tengan más presente. Conjeturando, también cabe la posibilidad de que el ranking distorsionase la percepción de progreso de los alumnos más participativos, ya que estos, al verse en las primeras posiciones, podrían considerar tener un muy buen progreso global, cuando en realidad el ranking solo da información sobre el progreso relativo del alumno en comparación con sus compañeros.

5.2. Artículo 2 - Comparación entre los efectos de las redes sociales y la gamificación en el rendimiento académico

En el segundo artículo continuamos la línea de investigación de la gamificación entrando en el terreno de las redes sociales, una herramienta que, pensamos, podría ser útil en combinación con la gamificación para fomentar el aprendizaje colaborativo, en contraposición con el enfoque competitivo de la primera experiencia. En este artículo comparamos una experiencia muy similar a la del artículo 1 con otra en la que se utilizan redes sociales en el mismo contexto y con la misma finalidad que la gamificación, para poder posteriormente comparar una y otra con respecto a una experiencia e-learning tradicional, analizando el impacto de cada una de estas dos experiencias en el rendimiento académico, la participación y la actitud de los alumnos. El objetivo de este artículo es profundizar en el conocimiento de los efectos de la gamificación y de las redes sociales en el aprendizaje cuando son utilizadas independientemente y entender cómo uno y otro enfoque podrían complementarse en una herramienta de gamificación social.

Al igual que en el artículo anterior, estas experiencias educativas tienen lugar en el curso "Capacitación en el uso de las TIC". A los alumnos del grupo que denominaremos "experimental gamificado" se les ofrece la misma herramienta de gamificación presentada en el artículo 1, mientras que a los alumnos del grupo "experimental social" se les ofrece una red social basada en la plataforma Elgg, con vídeo-tutoriales relacionados con los contenidos del curso y las habituales herramientas y funciones propias de las redes sociales como el muro de actividad o los seguidores. Ambas herramientas son de uso opcional para el alumno, y se consideran complementarias a la plataforma e-learning tradicional, a la que también tienen acceso ambos grupos experimentales. El grupo de control únicamente tiene acceso a la plataforma e-learning tradicional.

Todos los alumnos involucrados en el experimento se sometieron a cinco pruebas distintas, cuatro de carácter práctico (omitiendo la prueba inicial del experimento anterior) y una prueba final de carácter teórico, cada una con su correspondiente calificación. Cada alumno también recibió una calificación adicional en concepto de participación, calculada

en base a sus intervenciones en las actividades presenciales y online. El análisis de estas calificaciones muestra que, de forma significativa, ambos grupos experimentales superaron al grupo de control en todas las pruebas prácticas, con el grupo experimental de redes sociales superando también al gamificado en dos de las cuatro pruebas. Al mismo tiempo, y en línea similar con experimentos anteriores, el grupo de control superó a ambos grupos experimentales en la prueba teórica. Estos resultados reafirman la hipótesis planteada en la discusión del primer artículo, mostrando que ambos instrumentos experimentales fomentan la adquisición de habilidades prácticas, pero menoscaban hasta cierto punto el aprendizaje de los conceptos teóricos subyacentes. Al igual que antes, conjeturamos que esto se debe a que ambos instrumentos fueron diseñados para fomentar el aprendizaje práctico y no el teórico.

El análisis del nivel de uso de cada instrumento por parte de los alumnos nos permite observar otros aspectos interesantes. Analizando el nivel de uso de la red social podemos ver que, independientemente del número de contribuciones realizadas por el alumno, los alumnos de este grupo superaron al grupo gamificado y al grupo de control en las calificaciones de las dos primeras pruebas, siendo esta diferencia significativa. Conjeturamos que los efectos positivos de la red social en el aprendizaje afectan tanto a usuarios activos, aquellos que realizan contribuciones, como a los pasivos, que se limitan a leerlas. Otra posibilidad es que los contenidos educativos basados en vídeo y presentes en la red social hayan tenido un efecto notable en el trabajo práctico de los alumnos en esas dos primeras pruebas, aunque no disponemos de datos para confirmarlo. También podemos observar que, dentro de cada grupo experimental, los alumnos con un nivel de uso más alto de cada instrumento obtuvieron mejores calificaciones en la prueba teórica que aquellos con un nivel de uso bajo o nulo, lo que lleva a pensar que el nivel de uso de los instrumentos puede ayudar a predecir el rendimiento académico del alumno, siendo este, de hecho, uno de los temas con los que continuamos nuestra línea de investigación. Por último, comparando ambos grupos experimentales, los resultados muestran que los usuarios activos de la red social obtuvieron mejores calificaciones en la prueba teórica que los usuarios activos del sistema gamificado, lo que sugiere que las características y mecanismos de la red social tuvieron mayor impacto en el aprendizaje teórico que los del instrumento gamificado.

En relación a la participación, resulta curioso ver qué el grupo de control fue el que más participación tuvo, seguido del grupo de red social. El análisis pormenorizado muestra que los usuarios activos de la red social tuvieron un nivel de participación notablemente más alto que cualquiera de los otros grupos, lo que parece lógico al tratarse de una plataforma colaborativa que invita a ello. Por el contrario, el grupo gamificado tuvo, en general, menor participación que todos los demás, incluido el grupo de control, lo que lleva a pensar que el enfoque competitivo de este instrumento no incita a los alumnos a participar y colaborar entre ellos. Sin embargo, no podemos generalizar estos resultados ya que los instrumentos experimentales ofrecen otras maneras de interactuar con profesores y compañeros, así como formas alternativas de contribuir y participar remotamente, que no fueron tenidas en cuenta para calcular el nivel de participación de los alumnos. Estas alternativas podrían estar haciendo que los alumnos minimicen su asistencia a clase y dejen de utilizar las vías de participación tradicionales, reduciendo de esta forma su nota de participación.

Vistos los resultados, podemos tratar de dar respuesta a la segunda pregunta de investigación: PI2 ¿Cuales son las diferencias entre el uso de gamificación y el uso de redes sociales en e-learning en relación al rendimiento académico de los alumnos? Los resulta-

dos aquí expuestos apuntan a que, aunque ambos instrumentos parecen tener un cierto impacto en el aprendizaje, las redes sociales tendrían un efecto ligeramente mejor que la gamificación en el rendimiento académico, especialmente en relación a la adquisición de conceptos teóricos. Aparentemente, las redes sociales tendrían también un efecto más inmediato, ya que podemos observar cómo el uso de la red social supuso mejoras en las calificaciones de todas las prácticas, mientras que el uso de gamificación solo tuvo efecto en las dos últimas. Sin embargo, las diferencias encontradas son pequeñas y las causas de estas no están claras, por lo que serían necesarios más estudios para confirmar estas hipótesis. En todo caso, sí podemos concluir que las redes sociales generan un nivel de participación notablemente más alto entre sus usuarios, en contraste con los bajos niveles detectados entre los usuarios de la plataforma gamificada. Todo esto nos invita a pensar que la gamificación debería estar enfocada en los aspectos sociales y de aprendizaje colaborativo, al resultar más efectivos, sino para mejorar el rendimiento académico, sí para fomentar la participación. De hecho, pensamos que una manera de hacer esto sería combinar gamificación y redes sociales, enfocando todas las herramientas y mecanismos de motivación de ambos instrumentos hacia el aprendizaje colaborativo.

Dejando de lado los efectos de uno u otro instrumento, no podemos cerrar esta discusión sin volver a poner el foco en uno de los principales problemas encontrados: las bajas tasas de uso de los instrumentos experimentales. El análisis de la red social muestra unas métricas de interconexión entre alumnos realmente pobres, con solo un 2 % establecido de las posibles interconexiones en la red. Aunque es una posible señal de la baja actividad de los alumnos en la red social, también podría deberse a que ni la red social ni las actividades promovidas por el profesor estaban realmente dirigidas a establecer conexiones entre alumnos. Otra métrica que nos indica un bajo uso de los instrumentos son los filtros de actividad establecidos por los formadores. Solo un 34 % de los alumnos del grupo de red social pasaron este filtro, con al menos 20 contribuciones realizadas a través de los distintos mecanismos de la red social en al menos 3 módulos distintos del curso. En cuanto al grupo gamificado, solo un 24 % pasaron el filtro de actividad mínima, con al menos 8 trofeos o medallas conseguidas, lo que representa un 20 % de todos los trofeos y medallas que se podían llegar a conseguir. Los motivos y posibles soluciones para la falta de uso del sistema gamificado ya fueron abordados en la discusión del artículo anterior. Respecto a la red social, los motivos aducidos por los alumnos para no utilizarla fueron, en primer lugar, la falta de tiempo o interés, y en segundo lugar, el hecho de desconocer la existencia de la plataforma. De nuevo, parece importante mejorar la información proporcionada a los alumnos sobre cada instrumento y sus potenciales beneficios. También creemos que en futuros experimentos los alumnos deberían disponer de un único instrumento de aprendizaje online, ya que el disponer de varias plataformas distintas y que los instrumentos experimentales sean opcionales sin duda también contribuye a su falta de uso. Por último, y como línea de trabajo futuro, pensamos que la combinación de gamificación y redes sociales también podría ser positiva para fomentar la actividad de los alumnos. La gamificación podría utilizarse como motivación extrínseca para conseguir que los alumnos empiecen a utilizar y contribuir a la red social durante el comienzo del curso y que, rápidamente, esta se convierta en una fuente de contenidos útil, de forma que el alumno adquiera una motivación intrínseca para seguir utilizándola.

5.3. Artículo 3 - Predicción del rendimiento académico mediante el análisis de una red social gamificada

En el tercer artículo abordamos la combinación de gamificación y redes sociales en un único instrumento de gamificación social. A diferencia de los artículos anteriores, en vez de tratar aquí sobre los efectos del instrumento experimental en el rendimiento académico, en este caso investigamos la capacidad del instrumento para predecir dicho rendimiento. Este cambio de enfoque se debe a las observaciones realizadas durante los experimentos previos, donde se identificó una cierta correlación entre los usuarios más activos de la red social y un mayor rendimiento académico. La técnica conocida como SNA (social network analysis) nos permite analizar la estructura y los patrones subyacentes a una red social para obtener información sobre los usuarios. El objetivo de este artículo es doble: primero, estudiar mediante SNA la estructura de la red social generada con un instrumento educativo de gamificación social para caracterizarla y ver sus similitudes con otros tipos de redes sociales; y segundo, estudiar la capacidad de las métricas de dicha red para predecir el rendimiento académico de los alumnos.

El diseño del instrumento experimental utilizado en esta investigación es fruto del conocimiento y de la experiencia adquiridos durante las investigaciones presentadas anteriormente. Basado en la plataforma Elgg, se trata de una herramienta con funciones y características de red social, complementadas con funciones educativas adicionales y con mecanismos de gamificación. Algunas de sus características más destacadas son el sistema de corrección por pares para las actividades propuestas a los alumnos, así como un mayor foco de la gamificación en los aspectos sociales y de aprendizaje colaborativo. Al igual que en experimentos anteriores, este se desarrolló durante una de las ediciones del curso "Capacitación en el uso de las TIC". Al comenzar el curso todos los alumnos fueron dados de alta en la plataforma e introducidos a la misma durante las clases presenciales. Los alumnos la utilizaron durante las 15 semanas de duración del curso. Al finalizar este, la estructura de la red social fue analizada mediante SNA, calculando diversas métricas individuales y globales que nos permitiesen caracterizar la red e identificar relaciones con el rendimiento académico de los alumnos.

A continuación exponemos los resultados del análisis. En cuanto a las características de la red, el coeficiente de agrupamiento medio y la longitud de camino media comparados con los de grafos del mismo tamaño generados aleatoriamente, así como algunas otras métricas de la red, nos indican que podríamos estar ante una red de mundo pequeño (small world). Estas redes se caracterizan por poder establecer un camino corto entre dos nodos cualesquiera de la red, así como por su adaptabilidad, manteniendo esta característica ante los cambios que se puedan producir en la misma. Las redes de mundo pequeño se pueden encontrar en todo tipo de actividades humanas como los negocios o la educación. El hecho de que una red social gamificada tenga características de red de mundo pequeño nos hace pensar que es un enfoque adecuado y significativo para los alumnos, al generar una estructura similar a la de otras redes existentes en el mundo real y en las comunidades online. Además, conviene reseñar que en experimentos previos donde se usó una red social no gamificada en el mismo contexto educativo, la estructura resultante no tenía las características de una red de mundo pequeño, como muestra la estructura de la red social expuesta en el artículo 2. Esto nos lleva a pensar que las distintas funcionalidades y mecanismos de gamificación implementados en el instrumento de gamificación social han

resultado útiles para fomentar la interacción entre alumnos y el aprendizaje colaborativo, consiguiendo un instrumento educativo más significativo para los alumnos.

En relación a la capacidad predictiva de las métricas de la red, estas han sido analizadas mediante coeficientes de correlación, análisis factorial y regresión lineal múltiple para identificar y filtrar aquellas más fuertemente relacionadas con el rendimiento académico del alumno. El análisis de los coeficientes de correlación con el rendimiento del alumno sugiere una relación positiva con las métricas de centralidad del nodo, y una relación negativa con su coeficiente de agrupamiento. Esto último, confirmado también por el análisis factorial, indicaría que la disponibilidad de conexiones globales entre grupos de alumnos tiene importancia en los entornos educativos y que los alumnos encerrados dentro de una subred se verían afectados negativamente en su aprendizaje. De ser así, podríamos deducir que fomentar la comunicación e interacción entre alumnos o grupos de alumnos que no se conocen entre sí puede resultar positivo para su aprendizaje, algo que debería ser tenido en cuenta al diseñar experiencias de gamificación social en e-learning. Por su parte, el análisis factorial sugiere que las métricas obtenidas por los algoritmos de análisis de enlaces (HITS y PageRank) están relacionadas con las métricas de centralidad, pero que estas últimas tendrían mayor capacidad predictiva. Este análisis también muestra que la centralidad de grado o de vector propio tiene un mayor impacto en el rendimiento académico que la intermediación, lo que sugiere que es más interesante para el alumno tener una gran cantidad de contactos de los que obtener información, que el tratar de ocupar posiciones clave en la red que le faciliten el acceso a nuevas informaciones. Por último, el modelo de regresión lineal sugiere que la relación con el rendimiento académico sería positiva para la métrica de cercanía, y negativa para las métricas de centralidad de vector propio y excentricidad. La relación negativa del rendimiento con la excentricidad parece razonable, ya que estaríamos hablando de los alumnos que ocupan las posiciones más periféricas de la red. Sin embargo, la relación negativa con la centralidad de vector propio es contradictoria, ya que es no es de esperar una relación negativa entre la influencia de un alumno en la red y su rendimiento académico, especialmente cuando otras métricas de centralidad parecen tener una relación positiva. Estos resultados contradictorios podrían deberse a problemas de colinealidad.

Por último comentaremos algunas de las limitaciones del estudio. Una de ellas son las contradicciones que se han encontrado entre los resultados del análisis mediante coeficientes de correlación y mediante regresión lineal en cuanto a la influencia de algunas métricas de centralidad, en particular la centralidad de vector propio, en el rendimiento académico, que tendrán que ser resueltas en futuros estudios. Otra limitación es que el estudio ha sido realizado analizando el estado de la red social en un momento concreto, al finalizar el curso, pero el análisis del estado inicial o de estados intermedios de la red podría aportar información adicional sobre su relación con el rendimiento académico. Una última limitación es el tamaño de la muestra y el contexto concreto del estudio, que podría considerarse un impedimento para la generalización de los resultados. En última instancia, tratando de dar respuesta a la tercera pregunta de investigación, PI3 ¿Qué relación existe entre la actividad de los alumnos en una red social gamificada y su rendimiento académico?, podríamos decir que la posición del alumno en la red social, especialmente las métricas relativas a la centralidad del nodo, parecen tener relación con el rendimiento académico. Sin embargo los modelos aquí encontrados son poco representativos. Serían necesarios nuevos estudios, que incorporen técnicas de análisis alternativas y que tengan

en cuenta otras métricas adicionales a las de la estructura de la red social, como por ejemplo métricas reportadas por los propios alumnos, para encontrar modelos con mayor capacidad predictiva.

Capítulo 6

Conclusiones y trabajo futuro

En esta tesis hemos presentado tres estudios sobre los efectos y la relación entre la gamificación y el uso de redes sociales en el ámbito educativo, y su efecto sobre el rendimiento académico de los alumnos. Los resultados de estos estudios sirven como base para el desarrollo de esta línea de investigación a nivel global, mostrando algunas de las ventajas, y sobre todo, inconvenientes, de ambos tipos de instrumento y ofreciendo distintas vías para mejorarlos. Consideramos que los futuros estudios sobre gamificación y redes sociales podrían desarrollarse sobre la base de las conclusiones aquí alcanzadas con el objetivo de crear experiencias educativas más significativas, motivadoras y valiosas para los alumnos. A continuación resumiremos las principales conclusiones de estos estudios y las posibles líneas de trabajo futuro que hemos identificado.

6.1. Conclusiones

En el artículo 1, "Gamifying learning experiences: practical implications and outcomes", hemos mostrado que aunque la gamificación parece tener el potencial de motivar a los alumnos, resulta necesario un importante esfuerzo en su diseño e implementación para que dicho efecto sea generalizado y perdure a lo largo del tiempo. También se ha mostrado que, para que el efecto en la motivación del alumnos se traduzca en una mejora de su rendimiento académico, es necesaria una cuidadosa alineación entre el enfoque de la experiencia gamificada y los objetivos de aprendizaje planteados. Entrando en detalle, se ha mostrado que la gamificación con un enfoque competitivo, al menos con un planteamiento básico basado en el uso de puntos, medallas y rankings, puede tener un efecto muy limitado en el rendimiento académico, medido este a través de las calificaciones de los alumnos en ejercicios prácticos y teóricos. El enfoque competitivo parece apelar únicamente a un cierto tipo de alumno especialmente motivado por la competición y la comparación social con sus compañeros. De hecho hemos podido observar cómo este enfoque puede resultar inocuo o incluso negativo para la motivación de otro tipo de alumnos que prefirieron seguir la asignatura utilizando herramientas de e-learning tradicional. También se ha mostrado que la gamificación puede llevar a una distorsión en la sensación de progreso del alumno, como hemos podido comprobar contrastando la opinión sobre su propio progreso que tenía cada alumno con el valor de progreso real registrado en la plataforma. Estas distorsiones deben ser corregidas para evitar los problemas que de ello se pudieran derivar. En cuanto al rendimiento académico, en esta tesis hemos mostrado que la gamificación puede tener

impacto en la forma de aprender del alumno, por ejemplo mejorando su adquisición de habilidades prácticas; pero que también puede tener efectos inesperados, como en este caso, un efecto negativo en el aprendizaje de conceptos teóricos respecto a un sistema e-learning tradicional. En consecuencia, que los efectos en la motivación de los alumnos y en su comportamiento se traduzcan en una mejora de su rendimiento depende de diversos factores, de entre los que consideramos especialmente relevantes el diseño de la experiencia, los objetivos de aprendizaje y la forma de evaluación. De ahí que sea necesario hacer un importante esfuerzo en el diseño de experiencias gamificadas para conseguir que estas sean no solo motivadoras y significativas para el alumno, sino que también resulten beneficiosas para su aprendizaje.

En el artículo 2, "An empirical study comparing gamification and social networking on e-learning", hemos comparado el uso de gamificación y redes sociales en educación. Esto nos ha permitido observar cómo, ante sendos diseños que buscaban promocionar los mismos comportamientos, ambas herramientas han tenido un impacto similar en el aprendizaje de los alumnos, potenciando en ellos la adquisición de habilidades prácticas y menoscabando el aprendizaje de conceptos teóricos. Sin embargo las redes sociales han sido notablemente más efectivas en cuanto al fomento de la actividad por parte de sus usuarios, algo en lo que la gamificación competitiva ha tenido, por el contrario, un efecto claramente negativo. Esto nos sugiere que la gamificación podría resultar más beneficiosa en el ámbito educativo si estuviese enfocada en los aspectos sociales y cooperativos, al resultar estos más útiles para incrementar la actividad de los alumnos. También nos invita a pensar que ambos instrumentos combinados, gamificación y redes sociales, con sus respectivas funciones y mecanismos de motivación, podrían formar un buen tándem con el que fomentar el aprendizaje colaborativo. Otra de las conclusiones alcanzadas con este y el anterior estudio es que, por si solas, la gamificación o las redes sociales no resultan especialmente atractivas para los alumnos y que, por diversos motivos, estos pueden preferir el uso de los sistemas e-learnig tradicionales a los que ya están acostumbrados. Esto implica que, para que una experiencia de este tipo resulte atractiva, hay que trabajar cuidadosamente en diversos aspectos de la misma. Uno de ellos es la implicación del profesorado, ya que es en última instancia el responsable de presentar la herramienta a los alumnos, informarles de sus ventajas y beneficios, así como de fomentar un uso provechoso de la misma. Otro aspecto importante en el que trabajar es el diseño y la usabilidad de la herramienta. Dado que el uso de redes sociales y gamificación en el ámbito educativo es un enfoque innovador, muchas veces este se basa en tecnologías y herramientas poco maduras y escasamente integradas en el ecosistema de la institución educativa, lo que puede dificultar y lastrar su uso por parte de los alumnos.

En el artículo 3, "Social network analysis of a gamified e-learning course: Small-world phenomenon and network metrics as predictors of academic performance", hemos analizado la estructura de la red social generada en una experiencia de gamificación social para determinar sus características y evaluar hasta qué punto se asemeja a la estructura de otras redes sociales; así cómo para saber si a través de la estructura de la red es posible predecir el rendimiento académico de los alumnos con un modelo coherente y representativo. En relación a la primera cuestión, hemos observado que la red social generada puede calificarse como un mundo pequeño. Este tipo de red aparece naturalmente en diversos contextos de actividad humana como los negocios, la educación o las redes de amistad. Que en este caso también se genere una red con estas características nos lleva a pensar

que la actividad llevada a cabo por los alumnos a través de la red social gamificada es significativa y sigue patrones similares a los de otras actividades. En cuanto a la segunda cuestión, el estudio muestra que la posición de un alumno en la red social, especialmente las métricas de centralidad, guardan relación con su rendimiento académico, aunque los modelos obtenidos no son demasiado representativos y su capacidad predictiva es baja. Pese a ello, los resultados sugieren que invitar a los alumnos a involucrarse activamente en la red y darles la posibilidad de hacerlo mediante mecanismos que resulten de su interés es algo positivo para fomentar el aprendizaje colaborativo. La capacidad de analizar la estructura de la red social y sus distintas métricas a lo largo del tiempo también podría resultar positiva para profesores y administradores, pudiendo obtener información sobre el comportamiento de sus alumnos y sobre el impacto de las distintas acciones formativas.

6.2. Trabajo futuro

En línea con la discusión de los resultados y las conclusiones expuestas anteriormente, proponemos las siguientes líneas de trabajo futuro en el ámbito de la creación e implantación de experiencias educativas gamificadas:

- En relación al diseño de experiencias educativas gamificadas que resulten significativas y estén alineadas con los objetivos de aprendizaje, una línea de trabajo de gran interés es el estudio y evaluación de los marcos de diseño de gamificación elaborados por otros autores, como el marco teórico centrado en el usuario para la gamificación significativa de Nicholson y Studies (2012), el marco de diseño para la gamificación basado en el concepto de "átomos de habilidad" de Deterding (2015) o las heurísticas de gamificación propuestas por Roy (2017).

- En línea con los efectos observados de las redes sociales y la gamificación competitiva en la actividad de los alumnos, proponemos continuar trabajando en el desarrollo de los aspectos sociales de la gamificación, o gamificación social, en detrimento de los aspectos competitivos. Esto incluye el diseño y estudio de los efectos en el rendimiento de actividades gamificadas donde se desarrolle el aprendizaje colaborativo (p. ej. tareas por equipos, corrección por pares, roles), así como de sistemas de recompensas donde primen los aspectos cooperativos y sociales (p. ej. avatares, regalos, moneda virtual e intercambios y transacciones entre usuarios).

- Una de las limitaciones de gran parte de los estudios sobre gamificación en e-learning es que están ceñidos a su aplicación en cursos o asignaturas individuales. Sin embargo no hemos encontrado estudios de los efectos de la gamificación aplicada a nivel general en una institución educativa. Esto supondría no solo el uso de una plataforma gamificada de aprendizaje en los distintos cursos impartidos por la institución, sino también la incorporación de retos y recompensas de carácter institucional. De esta forma, además de expandirse las posibilidades de diseño de los mecanismos de motivación, estos, por su naturaleza institucional, podrían resultar más significativos para los alumnos. Dado que el principal reto de la gamificación es crear experiencias significativas, consideramos que sería de interés el estudio de los efectos de la gamificación en el rendimiento cuando es aplicada de forma general a una institución educativa, como una universidad o instituto.

- Para poder generalizar y matizar las conclusiones alcanzadas en nuestros estudios sería necesario continuar estudiando los efectos de la gamificación en otros contextos de educación online, como la formación profesional, formación de posgrado o en formaciones no regladas; así como en programas educativos con distintos objetivos de aprendizaje y formas de evaluación, tanto de carácter teórico como práctico.
- Respecto al análisis de datos en una red social educativa, sería de interés realizar nuevos estudios y probar distintas aproximaciones, como la minería de datos, para la obtención de modelos de predicción representativos que permitan obtener información útil para profesores, administradores y diseñadores instruccionales sobre el comportamiento de los alumnos y el aula en su conjunto durante la formación.

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