Universitat Autònoma de Barcelona

Pensamiento docente y efectos de la tecnología PowerPoint sobre el aprendizaje

David Chávez Herting

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Tesis Doctoral

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Doctorado en Psicología de la Comunicación y Cambio

Departamento de Psicología Básica, Evolutiva y de la Educación –

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Dedicatoria

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CAPITULO 1. INTRODUCCIÓN GENERAL

1.1. Las tecnologías educativas: desarrollo histórico del concepto y situación actual

En las últimas décadas, los avances de la industria tecnológica han transformado radicalmente la sociedad en básicamente todos los aspectos de nuestras vidas y, desde luego, la educación no es la excepción (Cabero, 2003). No hace demasiado, se requerían enormes computadoras con valores prohibitivos para realizar trabajos muy específicos, mientras que en la actualidad, existen tecnologías multipropósito accesibles en básicamente todos los hogares (López, 2009).

Actualmente, existen cerca de 20 revistas indexadas en la Social Sciences Citation Index (SSCI) especializadas en tecnologías educativas, lo que se traduce en unos 800 artículos científicos de alto impacto publicados anualmente respecto al tema. Sin embargo, todavía existen muchos mitos e imprecisiones respecto al uso de tecnologías en contextos educativos, y especialmente sobre el alcance de su impacto real. En ese sentido, ha existido una cierta tendencia a una perspectiva solucionista, que considera que las tecnologías eventualmente solucionarán muchos de los problemas actuales de la educación (Cabero, 2016).

A nivel práctico, las tecnologías educativas se han caracterizado por dos fenómenos: primero, un crecimiento exponencial de las tecnologías, que ha permitido el desarrollo de una enorme diversidad de herramientas disponibles, tanto para educadores como para educandos (Aguaded & Cabero, 2014); y segundo, la masificación de estas tecnologías, impulsada por diversos programas gubernamentales y de organismos internacionales (Area et al., 2014). Actualmente, es impensable que las instituciones educativas no cuenten con algunas de estas herramientas para apoyar la labor docente.

A nivel teórico, la tecnología educativa no ha logrado avances sustantivos en dilucidar qué tipo de tecnologías colaboran mejor en el proceso de enseñanza-aprendizaje. Para Lawless (2016), el panorama actual de las tecnologías educativas es "descorazonador en el mejor de los casos" (p. 173), mientras que Gros (2016) sostiene que "tampoco se aprecia una investigación acumulativa y, a menudo, se tiene la sensación de estar siempre formulando las mismas preguntas" (p. 2). Una crítica que se repite en Cabero (2003), quien defiende la existencia de una serie de "mitos" infundados que frenan el desarrollo científico de la disciplina. Nociones como el valor intrínseco de las tecnologías educativas, la reducción del tiempo de aprendizaje, la universalidad de su acceso, entre otros, tienden a crear una imagen de omnipotencia de las tecnologías educativas, que desde luego chocan con la realidad.

1.2.PowerPoint como tecnología educativa en educación superior

Entendiendo que tecnología educativa es toda aquélla tecnología dirigida o usada con fines pedagógicos, PowerPoint es, sin duda, la tecnología educativa más usada del mundo. Se encuentra en casi todas las escuelas y universidades, y su uso es tan difundido, que se ha convertido en un acompañante indispensable para profesores y estudiantes.

Dada su amplia difusión, es natural que muchos investigadores del área de la educación se interesasen por el uso que se le da en contextos educacionales. Sin embargo, y pese a que la evidencia sobre los beneficios pedagógicos del uso de PowerPoint en educación superior sigue siendo a día de hoy, como mucho, contradictoria (Baker, Goodboy, Bowman, & Wright, 2018), la mayoría de los estudios sobre su uso como tecnología educativa parecen asumir estos beneficios. Así, mientras muchos autores reconocen que las investigaciones no han logrado determinar un efecto positivo de PowertPoint en el aprendizaje de los estudiantes, en la práctica siguen investigando cuál es el mejor formato de PowerPoint (ver, por ejemplo, Kim, 2018; Smith-Peavler, Gardner, & Otter, 2019; Wisniewski, 2018). Como lo plantean Zdaniuk y sus colegas (2017), "a la luz de la inconsistencia de estos hallazgos, la mayoría de los investigadores decidieron ir más allá de la cuestión de si el uso de PPT mejora universalmente el desempeño de los estudiantes en relación con otras ayudas pedagógicas, y movieron su atención hacia las posibles condiciones bajos las que los PPT mejorarían el desempeño de los estudiantes" (pp. 467-468). Esto nos ha llevado al punto extravagante de encontrar en la literatura científica abundantes recomendaciones para maximizar la efectividad de una herramienta tecnológica cuya efectividad desconocemos.

En general, estas recomendaciones se centran en dos grandes grupos. Por un lado, estudios respecto al diseño de PowerPoint, especialmente basados en la dualidad texto-imagen. En esta tradición, tenemos a autores que no encuentran una clara asociación entre el uso de texto o imagen y el rendimiento de los estudiantes (Johnson & Christensen, 2011; Wisniewski, 2018); mientras que otros encuentran que el uso de imágenes mejora este rendimiento (Cladellas & Castelló, 2017; Pate & Posey, 2016; Smith-Peavler et al., 2019). Por otro lado, estudios respecto a la pertinencia de facilitarle a los estudiantes las diapositivas, ya sea en formato digital o impreso, completas o parciales. Los resultados son tan ambiguos como en el caso anterior, y existen estudios que muestran que la práctica de facilitar las diapositivas ayuda a mejorar el rendimiento de los estudiantes (Marsh & Sink, 2010), no tiene efectos en el rendimiento (Frank, Shaw, & Wilson, 2008), o directamente tiene efectos perjudiciales para este rendimiento (Worthington & Levasseur, 2015).

Para justificar el uso generalizado de PowerPoint, y en ausencia de evidencias claras respecto a sus posibles beneficios pedagógicos, los estudios se han centrado en un segundo aspecto: el nivel de satisfacción de los estudiantes con esta herramienta (Apperson, Laws, & Scepansky, 2008) o incluso el prestigio del profesorado asociado a su uso (Ledbetter & Finn, 2018). En esto, no hay ambigüedades, y la amplia mayoría de las investigaciones encuentran que los estudiantes prefieren que los profesores usen PowerPoint (Johnson & Christensen, 2011; Smith-Peavler et al., 2019; Zdaniuk, Gruman, & Cassidy, 2017), con unas pocas excepciones (Wisniewski, 2018). De allí que encontremos autores (Johnson & Christensen, 2011) que llegan a decir que “aunque el desempeño y medidas de aprendizaje tales como las calificaciones en los exámenes deberían ser las medidas primarias de la efectividad instruccional (…) la satisfacción de los estudiantes también es importante de considerar” (p.295), incluso si más abajo recuerdan el llamado efecto del Dr. Fox, que se refiere a “una serie de estudios en el que un actor no familiarizado con los contenidos del curso pretendía ser un profesor y consiguió excelentes evaluaciones de sus estudiantes gracias a sus habilidades interpersonales, pese a que su clase no tenía virtualmente ningún contenido educacional” (p. 296). Aunque los autores declaran que en su caso los contenidos sí eran educacionales, no queda claro si los resultados de satisfacción de los estudiantes pudieron verse afectados por variables sin relación alguna con la efectividad instruccional –que es, en definitiva, lo que demostraron los estudios del efecto del Dr. Fox (Naftulin, Ware, & Donnelly, 1973). Desde luego, no se trata en modo alguno de un caso aislado. Existen actualmente numerosos estudios que recomiendan el uso de PowerPoint, o se posicionan en el continuo texto-imagen, exclusivamente en función de la satisfacción de los estudiantes, sin controlar posibles variables externas que puedan explicar diferencias entre niveles de satisfacción en los distintos contextos de estudio.

De todo lo anterior se desprende otra característica de la mayoría de los estudios sobre el uso de PowerPoint en contextos educativos: usualmente se centran en un solo actor en la dualidad estudiante-profesor. Existen unas pocas excepciones a esta regla. Por ejemplo, James, Burke y Hutchins (2006) compararon una muestra de estudiantes y profesores para medir las diferencias en sus percepciones respecto a la utilidad de PowerPoint. Los resultados mostraron que estudiantes y académicos tenían una percepción muy similar respecto al uso de PowerPoint, aunque los académicos mostraron una perspectiva más optimista que los estudiantes respecto a sus beneficios. Sin embargo, usaron una muestra de 230 estudiantes de pregrado y apenas 33 académicos, lo que dificulta su representatividad respecto al conjunto de académicos de la universidad. Además, tanto estudiantes como académicos provenían únicamente del área de negocios, y el muestreo no controló activamente la posibilidad de respuestas duplicadas. De hecho, los académicos podían, a discreción, ofrecer créditos por participar en el estudio, y simplemente solicitaban a quienes ya lo habían respondido en otra clase que evitaran hacerlo de nuevo.

Como es usual en estos casos, los estudios se han centrado principalmente en los estudiantes (Klemenčič & Chirikov, 2015), lo que tiene algunos inconvenientes a nivel metodológico. Por ejemplo, Deslauriers y sus colegas (2019) mostraron que la percepción de aprendizaje de estudiantes universitarios en general aumentaba con métodos pedagógicos basados en instrucción pasiva (usando profesores bien evaluados) y no en instrucción activa (usando buenas prácticas pedagógicas). Lo que es más interesante: sus resultados sugieren que “las evaluaciones de los estudiantes respecto a la enseñanza deben tomarse con cautela puesto que se basan en las percepciones de los estudiantes respecto a su aprendizaje y podría favorecer inadvertidamente métodos pasivos de menor aprendizaje por sobre los enfoques pedagógicos activos y basados en investigaciones" (p. 6). Por lo tanto, basarse solo en las percepciones de los estudiantes para evaluar el impacto de PowerPoint es, como mínimo, insuficiente.

1.3.Objetivo de la investigación

De toda la revisión de la literatura anteriormente descrita, se desprenden dos necesidades básicas en el estudio del uso de PowerPoint en educación superior.

Primero, volver un paso atrás, y ante los resultados contradictorios respecto a los beneficios asociados a este uso, mirar críticamente a las razones para usar esta tecnología educativa. Ciertamente, estudiar cuándo el uso de diapositivas es una herramienta pedagógica efectiva es necesario. Pero primero, debemos entender por qué y cómo usamos PowerPoint. La mirada de los académicos ha sido ampliamente descuidada en los estudios sobre PowerPoint en contextos académicos, y si no sabemos las razones para usarlo, y los fundamentos pedagógicos para este uso, difícilmente encontraremos 'reglas de oro' respecto a su eficacia.

Segundo, integrar una mirada particularista de PowerPoint, opuesta al universalismo que ha caracterizado a muchos de los estudios anteriores. En efecto, consideramos que parte de las contradicciones halladas en las distintas investigaciones sobre el tema se deben a que no se han aplicado criterios específicos de cada disciplina. Resulta evidente que diapositivas textuales no tienen el mismo efecto para enseñar estructuras celulares en un curso de biología, y para enseñar el desarrollo de una teoría del aprendizaje en un curso de psicología.

Este trabajo pretende, por tanto, acercarse a una nueva comprensión de un fenómeno que es innegable e irreversible: PowerPoint ha llegado para quedarse en las aulas universitarias. Pero es necesario abordar este fenómeno desde una perspectiva más crítica, que no asuma la existencia de beneficios en el proceso de enseñanza-aprendizaje, sino que se base en evidencias sólidas para explicar cómo, ante la ausencia de evidencias, esta tecnología educativa ha podido cautivar a estudiantes y profesores de tal manera, que hoy resulta casi impensable no usarla.

1.4.Estructura del trabajo

El presente trabajo se divide en tres aproximaciones empíricas a la materia, en los capítulos 2, 3 y 4, y la presentación de conclusiones generales en el capítulo 5.

El capítulo 2, titulado "*el efecto de las diapositivas en la atención y aprendizaje percibidos*", indaga sobre las percepciones de los estudiantes respecto a sus propios procesos de atención y aprendizajes, comparándolo con una medida de la distribución aproximada de formatos de diapositivas (textual o visual). Específicamente, el objetivo principal de esta primera aproximación empírica fue examinar si el formato de las diapositivas se asociaba con diferentes disciplinas universitarias, y cuál era su efecto en las percepciones de los estudiantes respecto a sus niveles de atención y aprendizaje del curso. Se observará que, en este capítulo, se siguen enfatizando las percepciones de los estudiantes respecto a sus procesos de enseñanza-aprendizaje. Sin embargo, el foco no está tanto en la efectividad de las diapositivas propiamente como tales, sino la existencia de diferencias asociadas a distintas epistemologías basadas en las disciplinas particulares en las que se usaron. Esto en sí mismo representa un cambio relevante respecto a tradiciones investigativas previas, y profundiza en la dualidad universalismo-particularismo que se desprende de la sección anterior, en la que ha primado con diferencia la perspectiva universalista.

Para lograr este objetivo, se han planteado tres preguntas de investigación. Primero, ¿existen diferencias en los formatos representacionales de las diapositivas basadas en las disciplinas en las que se usan? En otras palabras, ¿depende el formato de las diapositivas de los contenidos propios de cada disciplina? Si asumimos una postura universalista, en el que PowerPoint tiene efectos generalizables a todas las disciplinas, sería razonable asumir que no debiesen existir muchas diferencias entre ellas. Además, considerando modelos teóricos previos tales como la teoría cognitiva del aprendizaje multimedia (CTML por sus siglas en inglés), sería esperable que a mayor cantidad de imágenes, mayor atención y aprendizaje percibidos (Mayer, 2009). Precisamente por ello, se incluyeron dos preguntas de investigación adicionales. Por un lado, ¿existe algún formato de diapositivas que contribuya a una atención focalizada de los estudiantes en el profesor o en la diapositiva? En otras palabras, si algún formato específico actúa como facilitador del aprendizaje, o como distractor. Y por otro lado, ¿existe algún formato de diapositivas que influya en las percepciones de aprendizaje de los estudiantes? El capítulo 2 abunda en los antecedentes teóricos que sustentan estas preguntas, por lo que no es pertinente detallarlos aquí, pero en términos generales, se ha asumido que presentar un contenido de forma verbal a través de dos canales (hablado y escrito) puede sobrecargar a los estudiantes y limitar el aprendizaje. Sobre la base de una muestra de 1316 estudiantes de 11 carreras, se procedió a indagar sobre los formatos más usados de PowerPoint, contrastando esta información con 54 académicos de las mismas carreras para responder a la primera pregunta; y posteriormente se procedió a analizar las percepciones de los estudiantes para dar respuesta a las preguntas de investigación 2 y 3. Los resultados parecen dar un primer indicio de diferencias entre las diferentes disciplinas.

No obstante, como se ha mencionado antes, uno de los objetivos de este trabajo fue el de ampliar la perspectiva, integrando las percepciones de los académicos. Los capítulos 3 y 4 detallan los resultados de un segundo estudio, en el que se indagaron patrones de uso, utilidad principal, y antecedentes de uso de PowerPoint a 106 académicos de dos universidades. Dado que el análisis tuvo dos fases metodológicamente muy diferenciadas, se ha optado por presentar esta segunda aproximación empírica en dos capítulos separados. Mientras el capítulo 3, titulado "*los patrones de uso de PowerPoint en ciencias naturales, médicas y sociales*", se propuso comparar la forma en la que los académicos de distintas disciplinas usaban PowerPoint, el capítulo 4, titulado "*¿por qué usamos PowerPoint en educación superior?*", aborda los factores que explican el uso de PowerPoint en educación superior aplicando un modelo de adopción de tecnologías proveniente de la literatura de los sistemas de gestión de la información. Como se observa, ambos capítulos, aunque se deriven del mismo estudio y los mismos datos, presentan enfoques muy diferentes aunque complementarios, que se relacionan directamente con los objetivos de este trabajo, de incluir a profesores y profundizar en las razones tras el uso de PowerPoint. Del mismo modo, estos enfoques complementarios tienen la ventaja de entregar una riqueza de resultados en base a sus metodologías diversas.

El capítulo 3 se centró especialmente en indagar, tal como su título lo indica, si existen patrones diferenciales en el uso de PowerPoint, cruzando datos en tres áreas: tipo de diapositivas, utilidad de las diapositivas, y antecedentes de uso. En el primer caso, se complejizó ligeramente la clásica mirada dual texto-imagen, y se usaron cuatro tipos de diapositivas: visual, textual, auxiliar, y combinada. Las diapositivas visuales incluyeron imágenes, gráficos, diagramas, y otras formas icónicas de presentar la información. Las diapositivas textuales incluyeron aquéllas que hicieron uso de citas textuales, definiciones, y otras formas similares de presentación de la información. Pero se agregaron diapositivas auxiliares, entendidas como aquéllas que, aunque basadas en contenido textual, no presentaban información como tal, sino que sólo proporcionaban una ayuda de organización de la información, como índices de contenido, títulos de unidades, entre otros. Se consideró como diapositivas combinadas cuando el académico indicaba preferencia balanceada por dos o más tipos de diapositivas. Además, se consideraron cuatro posibles utilidades pedagógicas primordiales para usar PowerPoint: ejemplificar contenidos, reflexionar críticamente sobre el contenido, memorizar conceptos claves, o estudiar para los exámenes. Finalmente, se consideraron ocho antecedentes del uso de PowerPoint, en base al mismo modelo que se aplicó en el capítulo 4: las expectativas respecto a la posibilidad de mejorar el desempeño profesional usando PowerPoint, la facilidad para usarlo, la disponibilidad material para usarlo, la influencia de los pares, el placer producido por su uso, el hábito de usarlo, la actitud hacia su uso, y la intención de usarlo. En conjunto, se desarrolló un perfil de uso para tres grandes macrodisciplinas (ciencias sociales, ciencias naturales, y ciencias médicas).

En base a la literatura, se esperaban tres resultados: primero, que las ciencias naturales y médicas usaran más diapositivas de tipo visual que las ciencias sociales; segundo, que las diapositivas textuales se asociaran a una utilidad basada en aprendizaje memorístico; y tercero, que las tres áreas del conocimiento evaluadas presentaron patrones diferenciados, tal como se desprendería de una perspectiva particularista de PowerPoint. Se observará que, al igual que en el capítulo 2, no se usó la clásica división entre ciencias duras y ciencias blandas, sino que se optó por ampliar las posibilidades, asumiendo que existen diferencias internas entre las carreras consideradas como ‘ciencias duras’ o como ‘ciencias blandas’. En general, se asumió que algunos de los resultados contradictorios encontrados en la literatura se pueden entender porque las categorías usadas para agrupar carreras, en los casos en los que efectivamente se usan muestras provenientes de distintas áreas del conocimiento, no permite capturar las características propias del contenido basado en las múltiples epistemologías que sustentan el conocimiento disciplinario. Cabe señalar que este capítulo en particular se basa fuertemente en una versión inicial de un artículo a publicarse próximamente (Chávez, Cladellas, & Castelló, *en prensa*).

El capítulo 4, por su parte, no consideró ni el tipo de diapositivas ni su utilidad pedagógica. Mediante un modelo de ecuaciones estructurales, profundizó en los antecedentes del uso de PowerPoint, adaptando un modelo de adopción de tecnologías denominado Teoría Unificada de Aceptación y Uso de Tecnologías, versión revisada (UTAUT-2, por sus siglas en inglés). Este precisamente es uno de los ejercicios más ausentes en la literatura actual. ¿Por qué, ante la ausencia de evidencia respecto a su efectividad, usamos con tanta frecuencia PowerPoint en educación superior, al punto de haberlo convertido en la tecnología educativa más usada del mundo? El capítulo trata de dar respuesta a esta interrogante, y analiza los resultados obtenidos a la luz de teorías previas, descubriendo nuevos problemas y desafíos para enfrentar. Aunque muchas voces han expresado su malestar con la forma en la que PowerPoint es utilizada, pocas veces se ha obtenido, de hecho, evidencia empírica para fundamentar estas críticas. Este representa un primer paso para entender cómo y por qué usamos PowerPoint, y desde aquí, mejorar las prácticas pedagógicas asociadas a su uso.

Finalmente, el capítulo 5 integra los resultados obtenidos en estas tres aproximaciones empíricas al fenómeno del PowerPoint, estableciendo el nexo necesario entre ellas. En este capítulo se discute la relevancia práctica y teórica de este trabajo, proponiendo futuras líneas de investigación que permitan fortalecer el estudio de PowerPoint a partir de estos resultados.

CAPITULO 2. EL EFECTO DE LAS DIAPOSITIVAS EN LA ATENCIÓN Y APRENDIZAJE PERCIBIDOS

2.1.Introduction

Many researches have been devoted to the use of PowerPoint, or similar technologies based on slides, in the educational field. However, how the courses' contents determine the kind of representation displayed by slides has seldom been investigated. Slides may contain images (like pictures, maps, sketches), graphs (diagrams, functions), or scripts (as bullet-point outlines) or text (definitions, excerpts, explanations) that involve different cognitive processing by the learner. Thus, each format demands specific uses of the available attentional and memory resources. Its effects on learning results have not yet been studied.

University majors differ in the natural way their contents are represented. Some disciplines, like Mathematics or Physics, deal with many formulae and graphs, while others focus on contents that involve many images (body parts, maps, planes, pictures) and a third group rely on speech and text (i.e. verbal contents). It is reasonable to expect these natural representations to prevail in the slides used. Nevertheless, in university classes there is always some sort of verbal explanation which takes place alongside the presentation of slides. Hence, verbal explanations may be associated with different kinds of slides, and each combination involves specific cognitive activities in order to process the information and understand the contents. Although the effects of individual professors making decisions when producing their slides is a component that cannot be neglected, the general discipline-effect should be strong enough to be observed and analysed.

2.1.1. Uses of slides in the university

Although new teaching methodologies (such as discussion-groups or problem-based learning) are gradually being incorporated in university classes, traditional lessons where the professor talks about a subject still prevail, particularly when theoretical contents are to be taught. In these classes, the use of some sort of slide-presentation is very common (Hill, Arford, Lubitow, & Smollin, 2012). For instance, more than two thirds of the professors use slide-presentations in at least one class each semester (Burke, James, & Ahmadi, 2009; Rickman & Grudzinski, 2000).

This situation has attracted a lot of research concerned with the advantages and disadvantages of static slides presentation (Baker et al., 2018). Among the advantages, students usually prefer slides instead of the blackboard because they can easily get the information displayed, either before or after the class. It has also been shown that slide-presentation improves learning (Koles et al., 2010; Scraw, 2001) and the interest of the audience (Seth, Upadhyaya, Ahmad, & Moghe, 2010). They are considered to be a notable aid in complex explanations (Hughes, 2003). The quality of text and diagrams is higher than when they are hand-drawn, and animations, drawings or videos can be embedded within the presentation for illustration purposes and learning improvement (Seth, Upadhyaya, Ahmad, & Moghe, 2010). From the professors' point of view using a presentation is less physically demanding than using the blackboard and the use of a computer-based technology provides a certain scent of modernity (Armour, Schneid, & Brandl, 2016) while the blackboard is associated with obsolete teaching resources.

Some inconvenient effects have nonetheless been declared. Cladellas and Castello (2017) observed that taking notes while the professor is using the blackboard is positive for the students, since it fosters an active role where representing properly and making sense of the contents is part of their work. There is a construction of the meaning conveyed by the professor through their utterances and whatever is written or drawn in the blackboard. On the other hand, verbal slides seem to embody all the knowledge that concerns the topics that are taught and, therefore, no further thinking is necessary. They usually provide a sense of completeness that triggers capturing the information rather than thinking about it. Since acute attention, as well as thinking and reasoning, is a necessary part of understanding and significant learning, verbal slide-presentations make students more oriented to memorisation, thus generating a shallow level of learning. A second positive effect of taking notes is that learning continues when they review the notes taken after the classes and persists making sense of the contents (Bohay, Blakely, Tamplin, & Radvansky, 2011; Piolat, Olive, & Kellogg, 2005).

Another outback of using slide-presentations is that the relationship between professor and student becomes less human and more pre-configured and structured (Harnett, Römcke, & Yap, 2003). Verbal and nonverbal communication is placed in a second plane, while the technological presentation becomes central, despite human communication have proved to have positive effects on learning (Richardson, 2008). In some cases, focussing on the slide-presentation may completely deflect students' attention from the professor's explanations, making them useless (Costa, van Rensburg, & Rushton, 2007). Results found by Castello and Cladellas (2013) show that students do not only perceive to have learned more, but they also have a greater achievement when assessed, when their professor does not use slide-presentations. The explanation provided by these authors focusses on the idea that without slides the students themselves must elaborate the information conveyed by their professor, while when verbal slides are present, they concentrate on hoarding the information.

Cladellas et al. (2013) suggested that rather than the use of slide-presentations in the classes, the type of representation included in the slides is the key aspect to be considered. Images and graphs may favour understanding and learning while slides with plenty of verbal contents may hinder it (Cladellas & Castello, 2017; Lin & Atkinson, 2011). Many researchers argue that verbal slides make students focus on them rather than in the explanations provided by their teachers; in the best case, then have to alternate their attention from one source to the other, something that is very energy-consuming and deplete their attentional resources fast (Amare, 2006; Erwin & Rieppi, 1999).

2.1.2. Slide's Design and Cognitive Processes Involved

Understanding multimedia learning materials usually presented in textbooks and educational web sites involve encoding visual and verbal contents (Mason, Tornatora, & Pluchino, 2013). It has been demonstrated that properly designed multimedia materials improve learning and understanding (Mayer, 2009; Sweller, 1999; Van Merrienboer, 1997). Mayer's (1999) multimedia principle defined the limit of multimedia learning as a function of the verbal and nonverbal formats of the learning materials. The Cognitive Theory of Multimedia Learning (CTML, Mayer, 2009, 2014) states that when verbal and nonverbal information are simultaneously presented, learners make a verbal representation of the textual contents and an image representation of the nonverbal data, which are integrated afterwards. This theory has three suppositions: first, working memory has two independent channels, one for verbal contents and another for nonverbal contents; second, each channel has a limited capacity for processing its input, something that determines the limit of multimedia learning; and third, the need of active processing by the learner, encoding synthetically the new information and connecting it to existing knowledge structures (Mayer, 2009). Mayer's theory is based on Paivio's (1986) Dual Coding Theory, which establish that human cognitive system is composed of two specialised subsystems: one for verbal contents and another for nonverbal contents.

CTML theory, alongside with Cognitive Load Theory (CLT, Paas & Sweller, 2014; Plaas, Moreno, & Brünken, 2010; Sweller, Ayres & Kalyuga, 2011) strongly suggest to present verbal materials in oral format accompanied by images in order to exploit both working memory channels (Ginns, 2005; Low & Sweller, 2014; Schweppe & Rummer, 2016). The distribution of information in the two subsystems avoids a cognitive overload (Mayer & Moreno, 2002; Moreno & Mayer, 1999).

CLT stresses the role of an extraneous cognitive load. Sweller, Van Merriënboer and Paas (1998) define three types of a cognitive load: (1) an intrinsic cognitive load imposed by the interaction with what is being learned; (2) a germane cognitive load, which is due to devoting cognitive resources to schemata construction and automatization; and (3) an extraneous cognitive load, caused by an inefficient instructional design that does not take into consideration human cognitive architecture. Considering the limited capacity of the working memory, the display of a text on a screen while talking creates an unnecessary extraneous load that will obstruct learning (Paas, Renkl, & Sweller, 2003; Plass, Moreno, & Brünken, 2010; Sweller, 1994; Sweller, Ayres, & Kalyuga, 2011). If verbal materials are to be displayed, the recommendation is to use very short sentences (two or three words) or single concepts that can be orally developed by the lecturer (Mayer & Johnson, 2008). That would correspond with the bullet-points format commonly used in presentations. Furthermore, Ayres and Sweller (2014) showed that written texts and images cannot be focussed simultaneously, thus involving sequential processing. The implication is that mixing full text (not single words or very short sequences) with images divides students' attention and demands a higher energy expense and a larger time span to integrate the two representations.

Summarising the CTML and CLT approaches, the optimal situation is the combination of two different sensory channels and different processing resources, which happens when oral explanations are combined with visual elements. It is important to stress that hearing and reading do not meet all the requirements, because although different sensory channels are used the processing resources are the same (i.e. the language area of the brain) and that produces the overload. On the other hand, combining speech and images, which are coherent and are presented simultaneously, involves two different channels and two different sets of processing resources, making it adequate for parallel processing and ensuing integration.

Presentation software supports a flexible variety of representation formats, including written text, bullet-point outlines, static or animated images, diagrams, and equations (Schnotz & Bannert, 2003; van der Meij & de Jong, 2006). Besides, the different formats can be classified in three categories, as stated by Gladic-Miralles and Cautin-Epifani (2018): verbal, figurative and symbolic (the last one applies to mathematical equations or any symbolic set different from natural language). Each category may include a set of slide-formats (e.g. The verbal category may include full texts, short sentences, lists). Moreover, some slides can combine the two or three categories. Verbal and figurative categories match perfectly with the previous explanations provided by CTML and CLT models. It is not clear whether symbolic representations also have a specific channel and processing subsystem, notwithstanding.

A complementary classification arises from the Integrated Model of Text and Picture Comprehension (IMTPC) defined by Schnotz and Bannert (2003). This model states that text is represented by propositions while images are represented through a mental model. The propositional representation can be transformed in a mental model and, conversely, a mental model can be used to generate propositional representations (Schüler, Arndt, & Scheiter, 2015). Hence, the representations can be classified in descriptive (such as written or spoken text, and mathematical expressions) and depictive or iconic, as pictures, drawings, maps or graphs (Schnotz, 2005). Following this approach, verbal and symbolic internal representations would be descriptive, while images would be depictive. Schnotz and Bannert (2003) consider that the combination of descriptive and depictive representations can improve understanding in some cases and hamper it in some other cases. Complementation and cross-validation seem to be the key aspects. Coherent representations offer two different views of the same object (the contents that is supposed to be learned) sharing common aspects and contributing to the final meaning with details that are better represented in a descriptive or a depictive manner. Incoherent representations differ too much, or even contradict, and make integration difficult.

IMTPC model, hence, complements CTML and CLT approaches in a substantial manner: the point is not only using different channels and different processing subsystems; the internal representations must be congruent in order to be combined. Having two different representations of the same content allow cross-validation (providing meaning to ambiguous parts of one of the representations by means of the other representation) as well as complementation (some details will be better expressed by symbols or by images). The consequence is that the resulting, integrated representation is richer and has fewer errors than any of the two representations alone.

And a better representation leads to a better understanding, thus increasing the probability of connecting it with former knowledge.

Not all combination of oral explanations and images may be adequate. For instance, talking about anatomy can be easily connected with images or drawings of the actual body structures involved, thereby favouring congruence. However, it does not seem to be so straightforward talking about Plato philosophical ideas and make them congruent with some sort of iconic representation. This makes the discipline or, more specifically, its contents, a crucial variable in considering whether the use of slides improves learning or not (Burke, James, & Ahmadi, 2009; Soon, Jiong & Sheng, 2019).

2.1.3. Classification of Academic Disciplines

The most popular way of classifying academic disciplines is considering the presence or absence of a simple dominant paradigm (Biglan, 1973a, 1973b) which separate disciplines in “hard” and “soft” (Cashin & Downey, 1995; Smart & Elton, 1975; Smart & Elton, 1982). Hard disciplines are typically based on mathematics (e.g., Physics and Chemistry), while soft disciplines are based on language (e.g. Economics, Education, Law, and Sociology). Hard and soft disciplines usually have different teaching approaches: soft disciplines usually employ analysis and synthesis, while hard disciplines frequently rely on the memorization of principles, typically expressed by formulae, and application (Braxton, 1995; Entwistle & Tait, 1995; Franklin & Theall, 1995). Instructors in soft disciplines are frequently sensitive to educational innovation, using different types of evaluation procedures and student-centred techniques (Braxton, 1995, Garret, 2015; Webber, 2011).

Despite its popularity, the classification is rather vague and does not deal with disciplines that use both mathematics and language (such as Economical Sciences, among many others). An alternative way to group disciplines is using the representation format that their contents mostly involve. Parodi (2010) states that there exists a different path to construct knowledge associated with the discipline. The contents are expressed in graphical and mathematical ways in most Sciences, while verbal statements are overwhelming in Social Sciences. However, any discipline can be described by the relative weight of these types of representation.

Garrett (2016) demonstrated that the representations used in slide-presentations differ depending on the discipline. The main difference was detected in the amount of written text and the number of images and graphs. This researcher also observed that traditional hard disciplines usually used simple verbal expressions (typically in bullet-points format) while complex texts where common in traditional soft disciplines. Bartsch and Cobern (2003) found that displaying graphs and images that relate to the contents improve learning, but when this connection is not clear, the effect on learning is clearly negative. Graphic displays were found to be useful for the understanding of abstract contents, as well as for complex contents.

These contributions show that the use of slide-presentations is, in part, conditioned by the discipline: the type of contents and the prevailing kind of thought. However, each professor makes decisions concerning which slides they are going to use, accordingly to how they understand the topics and the ideas they may have about the teaching-learning process. Although it is reasonable to assume individual differences among professors, there seems to be two important dimensions that can be associated to the discipline: on the one hand, the type of representation that is dominant, which depends on the nature of the contents. On the other hand, a discipline-culture that states how to use language and what teaching and learning should be. Therefore, there should exist a discipline-related effect that influences which kind of representation is used in slide-presentations and how these presentations are used.

If these discipline-related differences actually exist, they must have an effect on students' learning. Specifically, in those cases where speech and images can be properly combined, a better representation of the contents should be expected and, consequently, a better understanding and learning results should yield (Smith-Peavler et al., 2019). Oppositely, disciplines that combine speech with textual information, or with graphical materials that are incongruent, should be expected to make understanding more difficult, thus limiting learning results.

2.1.4. Hypotheses of this study

In this study, we proposed three main hypotheses:

H1: Differences concerning the presence of image and text representations, associated to the discipline contents, are expected.

H2: In those disciplines that combine speech with visual slides, students are expected to declare to be attentive both to the lecturer and to the slides. Oppositely, in those disciplines that combine speech with verbal slides, the expectation is that students will declare to be attentive to the slides only.

H3: The perception of significant learning declared by students is expected to be higher in the disciplines that combine speech with visual slides.

2.2.Methodology

2.2.1. Data collection

A sample of 372 professors from a public university in Spain representing the different majors (Social Sciences, Health Sciences, Science and Engineering) were randomly selected to participate in the study. They were contacted by email to ask for their collaboration. Of the 372 professors, only 77 (20.7%) responded, twenty-three of whom (29.9%) were excluded because they did not teach lectures or because they did not use slides in more than half of their classes.

The percentage of slides' use, declared by individual professors, ranged from 87% to 95% of the lectures (virtually all the lessons, except the exams). Once grouped by majors, the average values oscillated between 90.4% and 91.3%, with no significant differences among majors. It is worth considering that those professors that did not use slides in at least half of their lectures were excluded from subsequent analysis, although they represented almost 30% of the sample. The remaining 70% of the lecturers used slides in virtually all their lectures notwithstanding.

The final count of professors who participated in the study was 54, belonging to eleven different disciplines. The candidate majors where those that at least had 80 students in the first course, in order to ensure a large number of respondents, considering that they could be distributed in different groups, some could refuse to answer or could be absent when the measurement was taken. Similarly, the majors where less than three professors accepted, and were adequate in terms of slides use, were discarded because the sample of students risked being too small. These conditions reduced to 11 the 17 the available majors with more than 80 students in the first year. This reduction notwithstanding the available majors cover all the main academic areas taught at the university: Health Sciences (Medicine, Psychology, and Veterinary); Pure Sciences (Physics, Math, and Chemistry); Social Sciences (Sociology, Economic Sciences, Primary Education, and Advertising and Public Relations); and Software Engineering. The rejected majors, due to the lack of interest in participating showed by their staff, were History, Law, Journalism (where the two professors that would have accepted to participate were also professors of Advertising), Infirmary, Translation and Interpreting, and Labour Relations. Since all the knowledge fields were represented, the absence of these majors does not generate a sampling problem.

An interview was scheduled with each professor. During the meeting, they were presented with different types of slides (see the figures in section 2.3.1) and were asked to identify the frequency, in percentage, they used each slide-format. This information was used to validate the percentages provided by their students, who were the actual source of the information studied.

2.2.2. Participants

A sample of 1316 students participated in the study. Students were attending their last year of their respective majors. Eleven different majors were sampled: Chemistry, Mathematics, Physics, Medicine, Veterinary, Psychology, Advertising and Public Relations, Economics, Sociology, Education, and Engineering.

The mean age for the participants was 22.58. Females were 59.1% of the sample. All students participated voluntarily and did not receive compensation. The distribution of students and professors (i.e. class-groups) per major is displayed in table 2.1.

Table 2.1. Distribution of professors and students by major

Majors	Professors (class-groups)	Students
Physics	3	76
Mathematics	4	99
Chemistry	4	86
Veterinary	4	81
Medicine	5	124
Psychology	4	101
Education	6	164
Economics	6	162
Advertising	6	132
Sociology	5	124
Engineering	7	167
TOTAL	54	1316

Students responded a questionnaire, originally devised by Roehling and Trent-Brown (2011) and previously adapted by the authors (2013). The total number of items in the questionnaire was fourteen. However, for the purpose of this research, only four of them were analysed – those corresponding with the goals of the study – though the full questionnaire was responded in order to preserve its psychometrical properties.

2.2.3. Procedure

In the first semester of the year 2017-2018, after at least two months of classes had been taught, three collaborators attended one lecture of each participating professors and distributed the questionnaire among the students. Professors had already agreed to finish the classes fifteen minutes before the regular time. Typically, students spent ten minutes to fill the questionnaire.

Research collaborators had previously accepted to participate in the data collection and had been trained by the researchers.

2.2.3.1.Independent variables

Format of the slides: Slides could be catalogued in two possible formats, as follows:

- Visual: diagrams, graphs, mathematical functions or images. Although they may contain words or short sentences, pictorial elements convey the core ideas. The examples used in the questionnaire are depicted in Figure 2.1.
- Textual: Slide filled with verbal content only. It may contain full sentences or paragraphs or be a short set of highlights. The examples used in the questionnaire are depicted in figure 2.2.

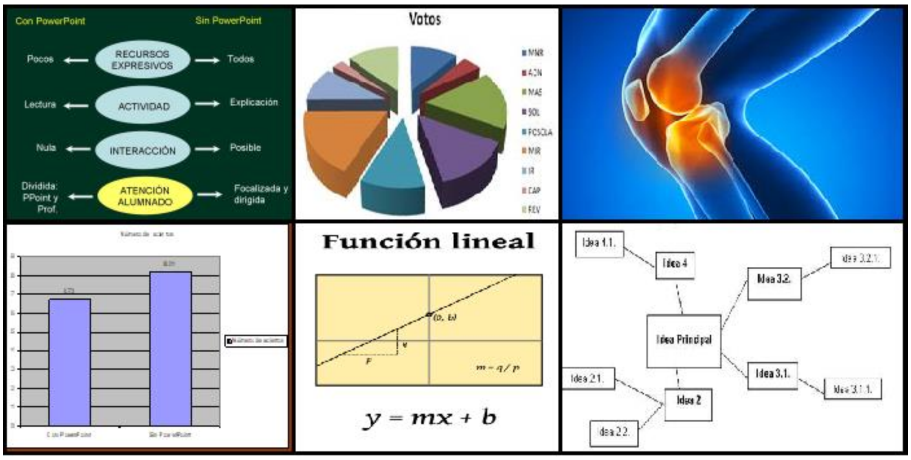


Figure 2.1. Examples of visual slides

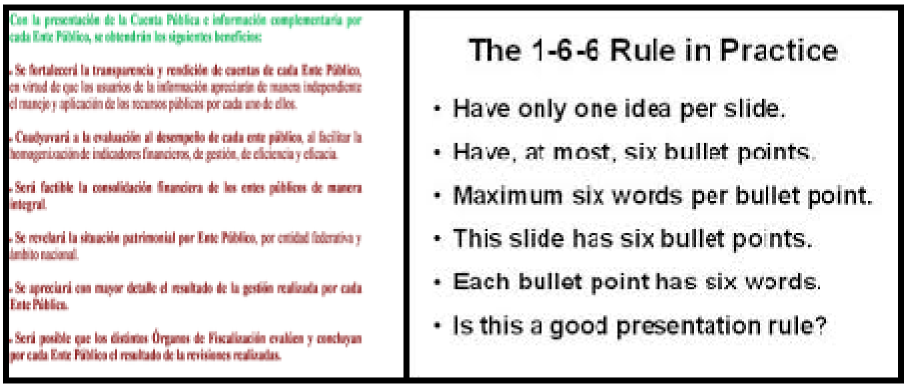


Figure 2.2. Examples of textual slides

2.2.3.2.Dependent variables

- Format of the slides: Percentage of each of the two slide-formats used in the classes. It is a numeric variable from 0 to 100. Students were instructed to verify whether the sum of the percentages was 100. This variable was used to test H1. Since individual responses were averaged, the resulting variable can be treated as continuous.

- Attention: The level of attention focused on the lecturer when using slides was evaluated by the following question: “Does the use of slides allow you to pay more attention to what the professor is saying?” The answer was “Yes” or “No”. The resulting variable was the proportion of “Yes” answers, and this value was used to test H2.

- Significant-learning perception: Significant-learning perception was evaluated using two questions. 1) "I think I learn in a more significant way when professors use slides in their classes (yes/no)". 2) I think I achieve a greater understanding when: (the professor uses slides as a support tool / the professor does not use slides at all). These two items were used to test H3. It is worth noting that the two items do not measure the same concept. In the second case, the question focuses on whether the contents could be fully conveyed by means of the professor's discourse alone, while the first question focuses on the improvement of significant learning through the combined use of discourse and slides (although slides could not be a necessary element).

2.2.4. Data analysis

A preliminary analysis was conducted to test the validity of student's responses. It consisted of testing the concordance of the proportions of each type of slides declared by the professors and the average of those declared by their students.

Concordance was computed as one less the sum of discrepancies for each type of slide. For instance, if a professor declared the proportions of 60%, 40%, and their students averaged 53%, 47%, the discrepancy would be computed as: $|60-53| + |40-47| = 7 + 7 = 14$, yielding to a concordance of $100 – 14 = 86\%$. That was the case with maximal discrepancy. Concordance ranged from 86% to 98%, being 94% the average.

Another preliminary analysis was conducted to examine whether differences existed in the class-groups belonging to each major. No significant differences were found.

Once students' objectivity was validated and differences attributable to specific class-groups were discarded, the following statistical analyses were carried out: descriptive statistics were computed and a multivariate analysis of variance

(MANOVA) for Majors and format slide was conducted. It was also calculated the observed power and partial eta-squared (η2) as a measure of effect size.

A Chi-square test was run to contrast attention and significant-learning responses, which were dichotomised.

SPSS (version 22.0) was used to perform the statistical tests and all of them were bilateral, with a Type I error set at 5%.

2.3. Results

2.3.1. Differences concerning the presence of image and text representations, associated to the discipline contents

To measure the differences between the majors and the format of the slides, we proceeded to calculate the average use of visual and textual slides in each of them. The results are detailed in Table 2.2.

Table 2.2. MANOVA, means, and standard deviations for visual and textual slides

Majors	Visual		Textual	
	Mean	SD	Mean	SD
Physics	51.08	2.27	49.18	2.28
Mathematics	51.15	1.87	48.74	1.88
Chemistry	41.72	2.06	58.28	2.06
Veterinary	50.52	2.49	49.48	2.49
Medicine	48.55	2.00	51.45	2.00
Psychology	35.92	2.01	64.08	2.01
Education	37.68	1.49	62.32	1.47
Economics	39.61	1.97	60.40	1.97
Advertising	43.10	2.29	56.98	2.28
Sociology	35.88	2.13	64.11	2.13
Engineering	36.04	1.39	63.86	1.37
MANOVA statistics				
F	9.42		9.48	
P	.000		.000	
η^2	.067		.068	
Observed Power	1.000		1.000	

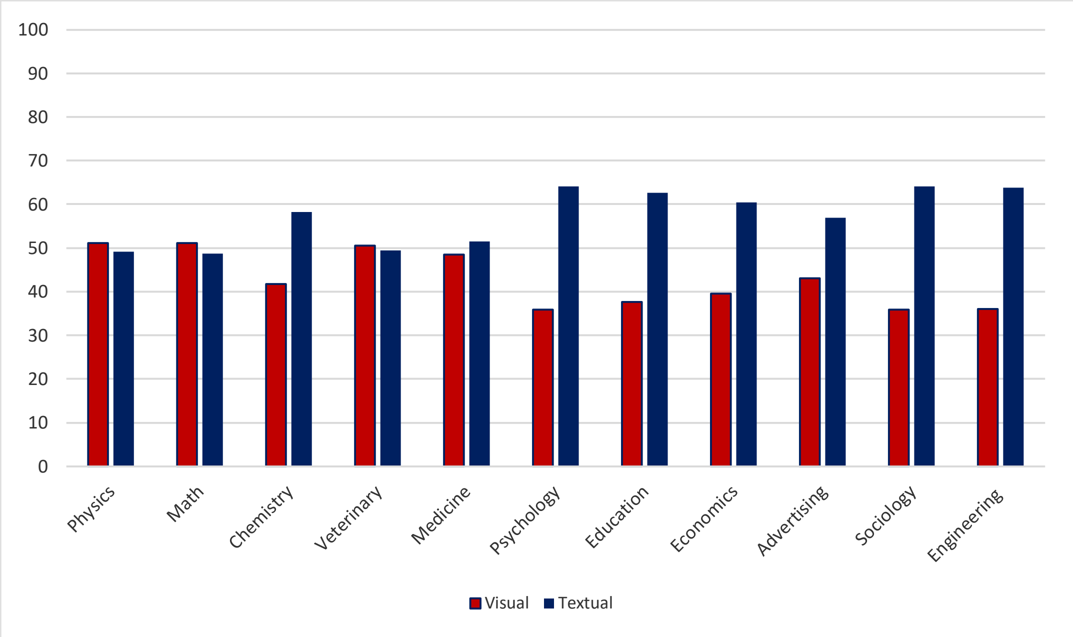


Figure 2.3. Average percentage of visual and textual slides by majors

Post-hoc analyses (Scheffé) were performed to get a more precise impression of the differences between groups. For visual slides, significant differences were observed in the following cases:

- Psychology, Sociology and Software Engineering majors had a lesser number of visual slides than Physics, Mathematics, Veterinary and Medicine majors.
- Primary Education had a lesser number of visual slides than Physics, Mathematics and Veterinary majors.

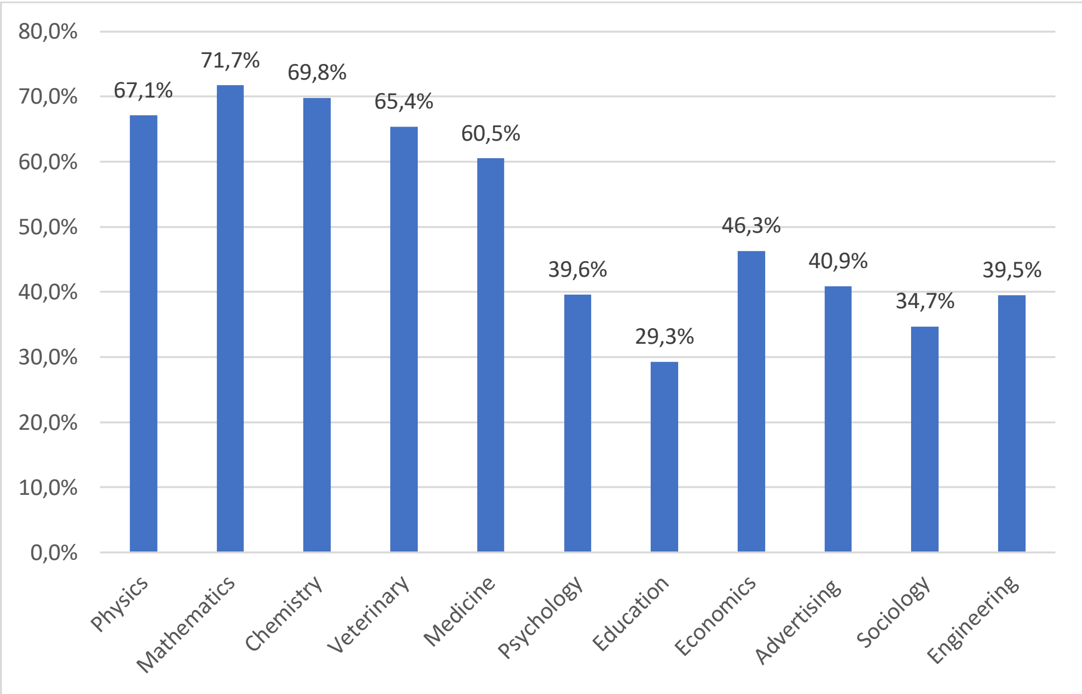
Concerning verbal slides:

- Psychology, Primary Education, Sociology and Software Engineering majors had a greater number of textual slides than Physics, Mathematics, Veterinary and Medicine majors.

2.3.2. Disciplines and attention

Subsequently, it was evaluated whether the use of visual slides was associated with greater attention to the teacher, as proposed in H2. In general, Mathematics (71.7%), Chemistry (69.8%), and Physics (67.1%) majors reported that slides helped them maintain attention in their professors, while Education (29.3%), Sociology (34.7%), and Engineering (39.5%) reported the lowest concentration rates with slides (see Figure 2.4).

Figure 2.4. Proportion of students that considered that the slides help increasing their attention to the professor speech

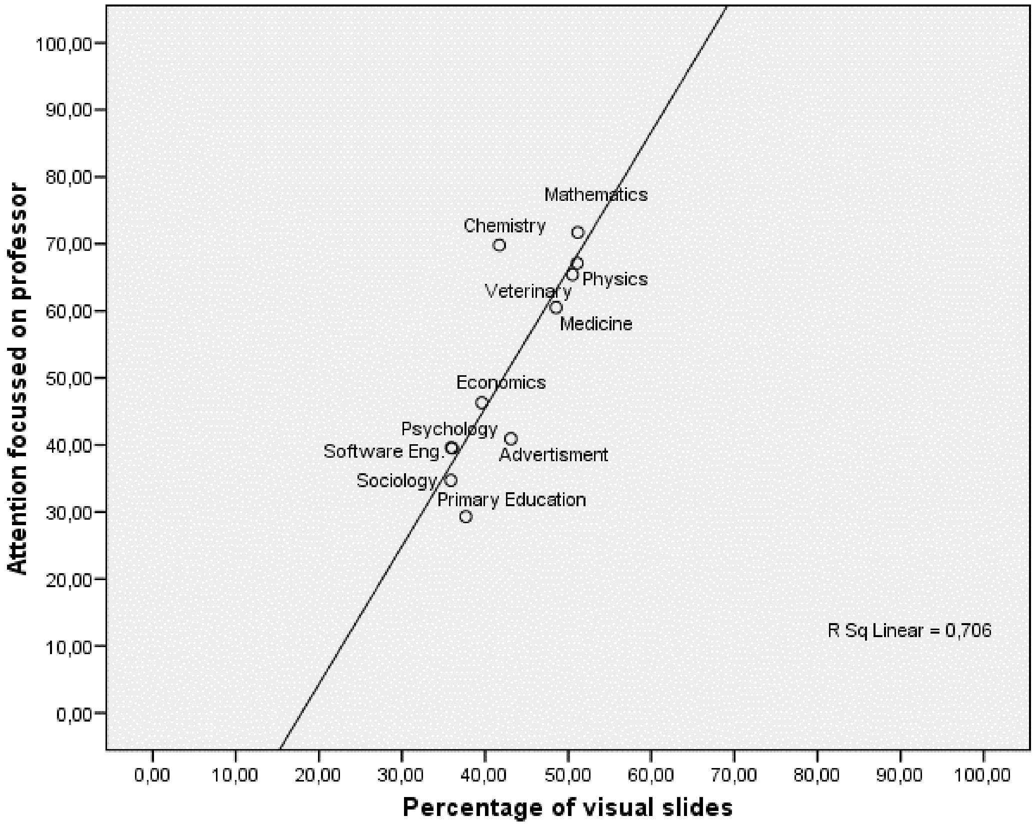


Since the proportion of "Yes" answers is a discrete variable, Chi square test was appropriate to contrast whether the proportions were similar or not. As is evident by observing Figure 2.4, there are important differences between the different majors, and indeed, the test yielded a Chi-square index of 109.63 (p=.000), indicating the presence of an association between both variables.

In Figure 2.5, the average percentage of visual slides is plotted with the average proportion of attention devoted to the professor in each of the majors. It includes a R^2 index of 0.706 which demonstrates a high linear relationship between the two variables.

In other words, the percentage of visual slides allows predicting a high percentage (70.1%) of the variance in students' attention to their professors.

Figure 2.5. Percentage of visual slides plotted with attention to the professor



2.3.3. *Students' perception of significant learning and slides format*

This hypothesis was evaluated by means of two questions: the first one had a yes/no answer depending on whether the students considered that the slides provided significant-learning; and the second one focused on when they better understand the contents: when using slides or when no slide at all was used.

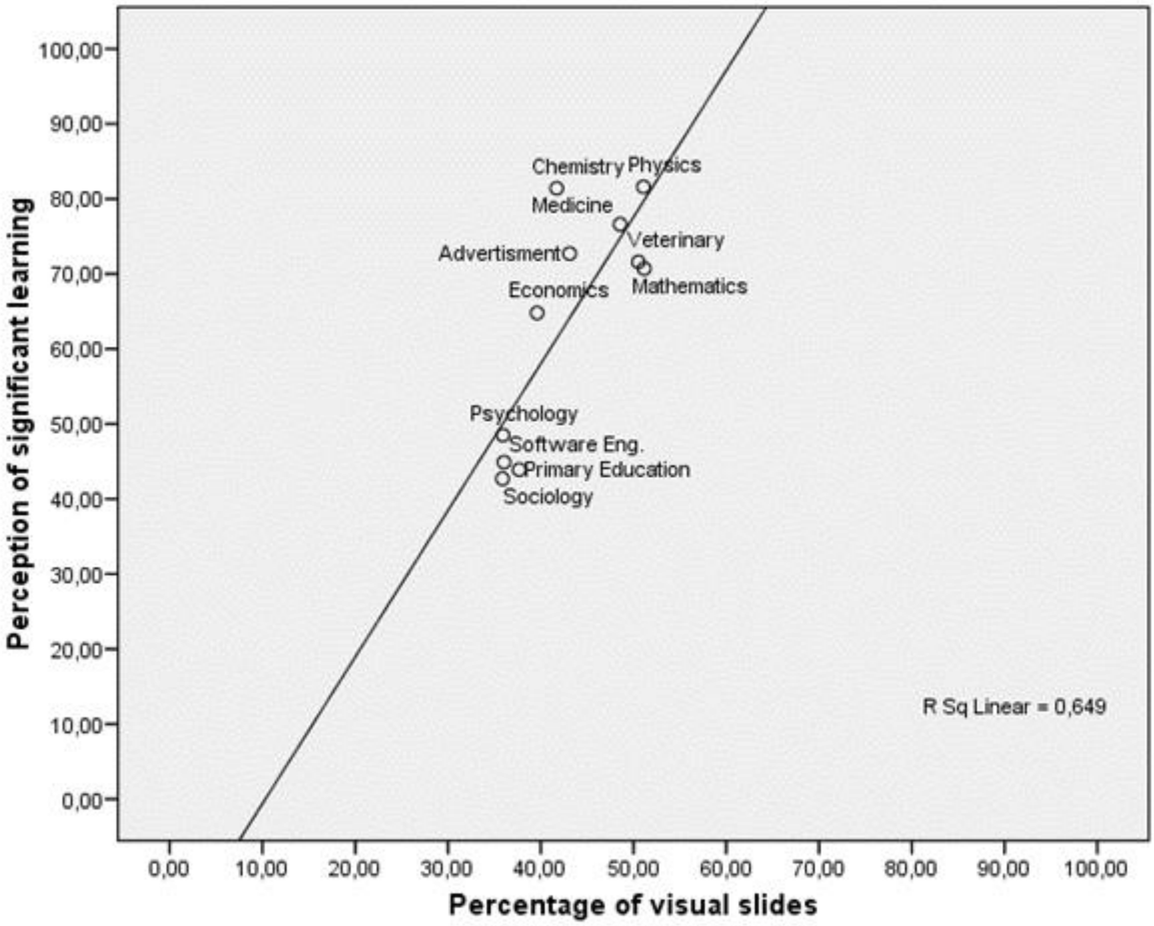
Table 2.3. Proportion of students that considered that slides and slides as a support tool increased significant-learning

	Slides	Support tool
Physics	81.6	78.7
Mathematics	70.7	77.6
Chemistry	81.4	80.2
Veterinary	71.6	95.1
Medicine	76.6	95.2
Psychology	48.5	29.7

Education	43.9	32.3
Economics	64.8	50.6
Advertising	72.7	44.7
Sociology	42.7	34.7
Engineering	44.9	29.3

Concerning the first question, the proportions of "Yes" were contrasted by means of a Chi square test, yielding an index of 118.79 (p = .000).

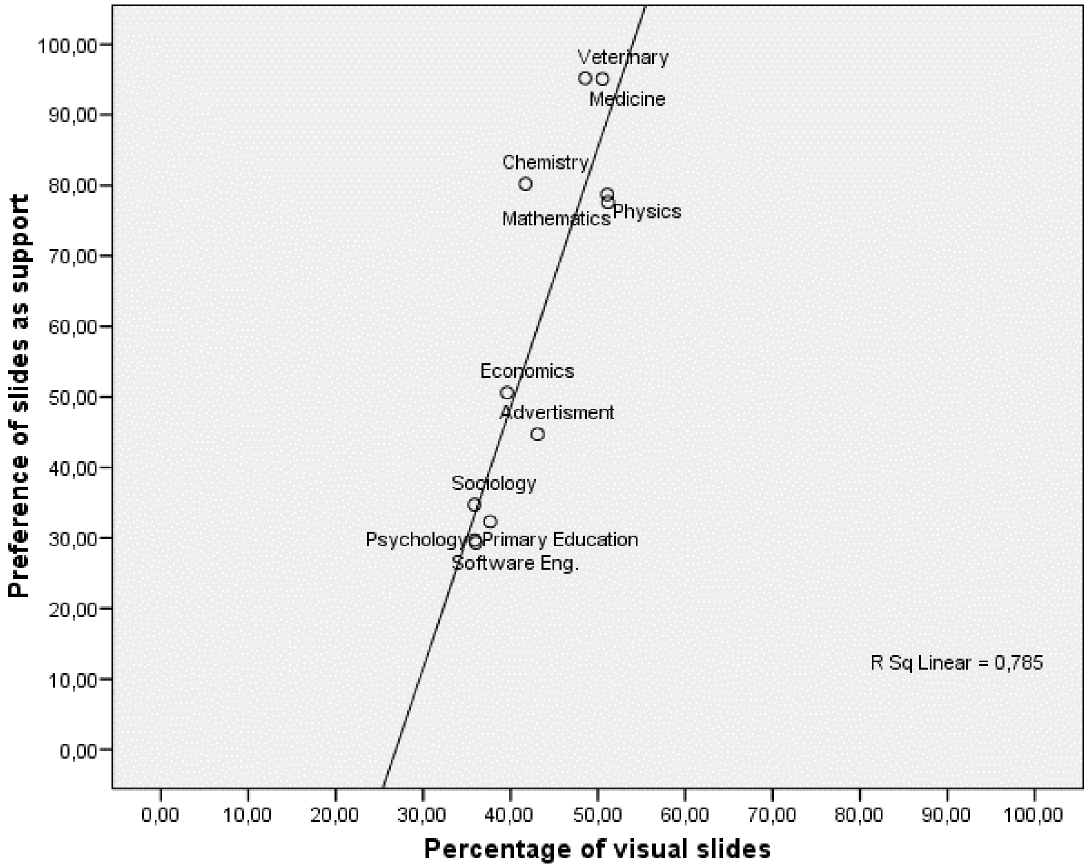
Figure 2.6. Percentage of visual slides plotted with perception of significant learning



The plotting and regression line of the percentage of visual slides and percentage of significant learning (both in average for each major) is depicted in Figure 2.6, and the R^2 value is 0.649, which also demonstrates an intense relationship.

The second question was analysed similarly. In table 2.3, the second column is formed by the percentages of students that chose the "support tool" option; it is worth observing that the complementary percentage was assigned to the choice "without slides". The proportion of preference for slides as a supportive tool, was tested by a Chi square contrast, resulting an index of 323.91 (p=.000).

Figure 2.7. Percentage of visual slides plotted with preference for slides as support



In this case, the regression index is 0.785, as can be seen in Figure 2.7, which is the largest of the three regression values. In the three plots, Chemistry is the major that shows a larger distance from the expected mean values, always scoring higher than expected for the intermediate use of visual slides.

2.4.Discussion and implications

The first result to be commented is the high percentage of slides' use in the classes of the studied majors. The average figure of 90.93% of use in lectures is very similar to that found by Smith and Caruso (2010). However, almost 30% of the randomly selected professors did not use slides in more than half of their lectures and were therefore excluded from the analysis. That means that the absolute percentage of use must be lower, although those professors that do use slides, virtually do it in every lecture.

Most of the professors that declared not using slides in more than a half of their lectures belonged to Pure Science majors: 15 out of 23 cases (65.2%). Most of these professors (13 cases) declared that they made an intensive use of the blackboard, while the remaining eight cases and two other Sciences' professors declared to use speech only. The use of slides was limited to very specific situations, if any. Hence, data obtained seem to show a polarized situation with no intermediate values of slides' use: most of the lectures use it in virtually all their classes, while a 30% of them almost never use slides.

The first hypothesis (H1) was concerned with the use of different kind of slides depending on the major. Results were clear in this concern, showing that professors of Physics, Mathematics, Medicine and Veterinary used significantly more visual slides than Psychology, Primary Education, Sociology and Software Engineering professors, which, conversely, used more textual slides. Overall, the majors from Pure and Health Sciences used more visual slides than other sciences, with the exceptions of Chemistry and Psychology. This fact suggests that the general academic area is somewhat less relevant than the specific major in determining the kind of slides used.

In the case of Chemistry, it should be noted that the contents are often expressed using formulae. This kind of encoding is certainly not visual, so it was probably included within the verbal formats. But it is not verbal either. Indeed, the use of formulas and the use of plain text is semiotically quite different. For people experienced in chemical notation, formulae are not "read" as text and decoded in the language area of the brain, corresponding to what Gladic-Miralles and Cautin-Epifani (2018) called "symbolic" format. Probably the same could be applied to mathematical equations, though their graphical expressions are clearly visual, while many chemical notations do not have a visual corresponding format.

The mismatch of Psychology is not so explainable. On the one hand, its categorization as a Health Sciences may be due to the applied therapeutic orientation of some of the psychological branches. However, the object of study is, in many occasions, not as much physical as in Medicine and Veterinary. Mind processes, for instance, are more complicated to include in a realistic picture, unlike most anatomical contents which are common in the other two disciplines. Indeed, the number of verbal slides in Psychology is one of the two highest proportions (alongside with Sociology). At least in this sense, it seems to be closer to the Social Sciences than the Health Sciences. The central explanation of the relative presence of visual slides seems to be associated to the nature of the contents: those majors with contents that can be naturally represented by images (body parts, structures) or that can be represented schematically by diagrams with precise meaning (e.g. interaction of forces) will spontaneously use these means with a high probability, particularly when the technological support makes easy to display such images. On the other hand, when no physical object exists or when diagrams are not precise (e.g. a combination of unweighted causes) image representations do not provide a clear advantage – or can even be misleading – when compared with verbal explanations (Bartsch & Cobern, 2003). Furthermore, the disciplines that used more visual slides have a set of contents that are more formalised, in the sense of having a strict meaning, including an extensive and precise jargon. That makes the use of verbal slides less ambiguous than in other disciplines with a lower level of formalization. Anyway, differences in the kind of slides used in dissimilar majors clearly exist and they cannot be explained by the academic area alone. That confirms H1.

The effects of these differences among majors' contents were analysed in hypothesis two (H2) and three (H3). The second hypothesis stated that the kind of slides used would be associated with the level of attention declared by students to the explanations provided by the professors (or, conversely, to the slides). Significant differences were observed in the four majors that used the most visual slides, as well as Chemistry. In the last case, the argumentation concerning the use of symbolic slides (although classified as verbal, as a consequence of the examples displayed in the questionnaire) also matches the central explanation: as predicted by the CTML (Mayer, 2009, 2014) the simultaneous use of two verbal sources (the verbal slide and the lecturer's explanation) overloads the verbal processing area, thus impeding paying attention to them at the same time. On the contrary, the combination of visual (or symbolic) slides with verbal explanations are processed by different channels, allowing the integration and complementation of both sources of information. Results thus match the expectations of H2.

Hypothesis three focused on the association between students' perception of significant learning/understanding and the number of visual slides used in their respective disciplines. The two questions associated to the perception of significant learning both yielded statistically significant differences, again involving the five majors mentioned in the previous hypotheses, plus Economic Sciences and Advertising. However, the students of the last two majors fall in a contradiction when asked if they prefer the use of slides as a support tool rather than no slides at all, being the last option chosen by the majority of them in the case of Advertising, and half of the students in Economics.

Overall, a clear positive association between understanding and the use of visual slides was found, with higher perceived understanding in the five majors with more visual slides (or symbolic slides, in the case of Chemistry), while less than 50% of the students in the majors with more verbal slides reported that the projected materials improved their understanding of the contents. When slides are evaluated as a support tool, Psychology, Education, Sociology, Engineering and Advertising prefer no slides at all, an indication that slide contents may be confusing. Half of Economics' students also would prefer avoiding slides. This percentages of students sharply contrast with the 95% preference for the use of slides obtained in Medicine and Veterinary majors, which are the two disciplines where visual objects are more connatural, as well as the preferences for its use in Mathematics (78%), Physics (79%) and Chemistry (80%). Hence, H3 is also confirmed.

However, the higher proportion of visual slides in the majors considered in this study represented roughly half of the total slides, something that indicates that textual slides also benefit from precise terminology and notation. Chemistry shows a similar pattern, although the percentage of visual slides only reached 41% of the major's slides. That leads to an unforeseen conclusion: both the visual nature and the formality of the contents improves the effectiveness of slides used in the classroom. Hence, the cognitive load or the use of independent perceptual channels is only part of the explanation. Well formalised contents, employing precise jargon and notation, are also helpful for understanding, despite being verbal. This result modulates the widespread idea that verbal contents are always counterproductive because of the cognitive overload. It seems that, when disciplines have a very formalised set of concepts, the use of such concepts in a schematic manner could be closer to the symbolic representation, despite using words. These words have a very precise meaning that make them closer to symbols employed in formulae. On the contrary, the disciplines that employ less precise terms or that relay on informal language, need to process both messages at the verbal area of the brain and solve many ambiguities associated to standard verbal expressions. For instance, “medial collateral ligament” uses three words, but with a precise meaning in terms of human anatomy. They are not associated to the general verbal meaning of such words. The level of precision, thence, is closer to symbolic expressions such as H_2O or $2 \cdot \pi \cdot r$ rather than a typical verbal sentence.

2.5.Conclusions and future research

This study makes the following main contributions:

1) Majors that are classified in the same academic areas use different slides formats. These differences are observed in Pure Sciences, Health Sciences and Social Sciences.

2) The amount of visual or textual slides is associated to the contents of the majors. Some of the disciplines deal with contents that are not easily represented in visual format and have a moderate level of formalisation, thus being expressed in complex verbal sentences.

3) Rather than the use of slides by itself, the correspondence of visual slides with the studied objects and the availability of a very precise jargon which may be interpreted in a symbolic manner are key factors in improving learning.

The practical consequences concern the way lecturers use slides. First, slides do not improve learning by themselves, they rather improve comprehension in the mentioned cases: when visual materials have a clear correspondence with the contents and when verbal expressions have a very precise meaning. Visual or verbal materials that do not have these properties may increase ambiguity and generate a cognitive overload thus making learning more difficult.

Secondly, traditional resources like speech or sketching ideas in the blackboard may be restricted when a slide presentation is used. In general, a populated slide-presentation becomes the main source of information in a classroom, relegating the intervention of the lecturer to a secondary role. Without slides – or with a reduced number of slides – lecturers might provide more examples, encourage the audience to focus on particular subjects, and allow themselves more opportunities to improvise. Some would adjust their voice, their volume and articulation, or otherwise control their use of language. They would, in general, employ more rhetorical skills. It is not unreasonable to think that the combination of speech with visual slides can stimulate a similar setting in the development of the lecture. The teacher, with no constraints imposed by the very text of the slide, can engage in a freer communicative repertoire, increasing the level of attention and learning of his students. Therefore, when slides are not clearly advantageous in conveying the information, they decrease the effectiveness of the professor's contribution.

Slides presentation is a frequent topic in many courses oriented to improve lecturers' performance, though in many occasions it is assumed that the use of such a technology is always going to be positive. This does not seem to be true. On the contrary, it is very important to make a clear distinction of when slides are useful and when they are counterproductive, controlling the appeal of the technological glamour associated with presentation software. These directions should be a more important part of these courses, rather than focusing only in the steps and tricks that permit to generate presentations.

At the light of the results, future research should focus in the cognitive format of the slides' contents, rather than the slide format itself. Symbolic representations, as well as verbal terms that have a very precise meaning, seem to be an important variable in conveying useful information to students. On the contrary, general verbal explanations, either short or long, might interfere the discourse of the lecturer and overload the cognitive system of the students. The future inclusion of techniques from the semiotic tradition can enrich the analysis of the content of the slides, categorizing more accurately different types of "texts" and their influence on the effectiveness of the slides in the teaching-learning process.

2.5.1. Limitations

This piece of research has its limitations. First, students' cognitive differences might exist and be associated to different majors. These differences could therefore influence the decisions taken by their professors in selecting a given type of slides and in their representation of the teaching-learning processes. Secondly, some majors were not included in this sample, though they have many students (law and history are the most salient ones). This was mainly due to the lack of voluntary participants who used slides in their lectures, but current design does not allow to detect whether this is a trend in these majors, or it rather was a coincidence. In any event, these two limitations do not contradict the results obtained. The differences observed are solid and clearly linked to the nature of the contents taught. However, data has been collected in a single – though big and prestigious – university, and it might not correspond to the same values of use in other universities. Hence, integrating data from different universities and countries could be a significant approximation to determine the solidness of the exact figures and their variation.

CAPITULO 3. PATRONES DE USO DE POWERPOINT EN CIENCIAS NATURALES, MÉDICAS Y SOCIALES

3.1.Introduction

In recent years the use of PowerPoint has been rather widely studied- both in schools and universities (Baker et al., 2018). Overall, the results are, at best, unclear (Baker et al., 2018, Craig & Amernic, 2006). Many authors agree that PowerPoint does not have a direct effect per se on student performance, but this performance rather depends on how instructors use PowerPoint, both regarding its design (Grech, 2018) and the objective the instructors pursued when using this tool (Garrett, 2016).

One of the factors that has not received enough attention is the difference in the use of PowerPoint between different disciplines, with some notable exceptions (e.g., Garrett, 2016). We believe that this factor likely has relevance for the application of good standards in relation to the design of PowerPoint material and its main purpose. Indeed, we conjectured that PowerPoint use would be differentiated by disciplines, which may impact design and usefulness, making it difficult to establish universal rules (Cosgun Ögeyik, 2017).

3.2.Literature Review

Studies on the effectiveness of PowerPoint have obtained differing and sometimes conflicting results (Baker et al., 2018). A major problem is that many studies lack the methodological rigour necessary to derive relevant conclusions (Moulton, Türkay, & Kosslyn, 2017), which may contribute to this divergence in results. For example, Shigli and colleagues (2016) found that PowerPoint is an effective tool for teaching gerodontology in a sample of undergraduate students in India, but with a design that only included a pre- and post-test after a single 30-minute intervention using PowerPoint, with no control group. Under these conditions it is obviously difficult to establish whether the success of the intervention really arises from the use of PowerPoint. However, even if we look at studies with more rigorous designs, inconsistencies still appear in the results (Baker et al., 2018).

These seemingly contradictory results are explained by Levasseur and Sawyer (2006), who pointed out that computer-generated presentations, such as PowerPoint, have a paradoxical effect related to two key concepts: arousal and dual coding. These authors argued that PowerPoint presentations display information in a sensory rich and interactive manner, increasing student's arousal and making the content more interesting and motivating, thereby improving academic performance. Indeed, a number of studies have found that PowerPoint is more visually appealing than using the blackboard (e.g., Blokzijl & Andeweg, 2005). In addition, according to the theory of dual coding (Paivio, 1986), the combination of visual (PowerPoint) and auditory (instructor) channels would enhance student learning. However, human beings have limited cognitive resources, so a sensory-rich content, such as what is presented in PowerPoint, may increase student's arousal but may also deplete the information processing resources more quickly. According to Levasseur and Sawyer (2006), because we process the visual content faster than the verbal content, a combination of images and sounds may overload the students' working memory, in such a way that all their resources focus on the more attractive but less relevant visual content of PowerPoint and fail in processing the often fundamental verbal content of the class. In fact, one study showed that students exposed to PowerPoint presentations tend to take textual and extensive notes of their content, which can limit the attention given to the instructor's comments (Huxham, 2010). Finally, the excessive use of texts in slides lead to an overload of information to be processed through the use of two simultaneous verbal stimuli (written and spoken), which prevents the students from integrating the information (MacKiewicz, 2008; Wisniewski, 2018). In other words, design and teaching practices are key to the effect of PowerPoint on students. In fact, Pate and Posey (2016) believe that "failures in educational delivery when using PowerPoint lectures may be due to improper use of PowerPoint and multimedia design principles" (p. 238).

3.2.1. The Design of PowerPoint

The main postulates of the theory of dual coding have been adapted in accord with multimedia learning theory, which is based upon three basic principles: the existence of dual channels to process visual and verbal material, a limited processing capacity, and an active cognitive processing capability to select and organize verbal and visual information and then integrate it with prior knowledge from long-term memory (Mayer & Moreno, 2003). For example, Roberts (2018a, 2018b) found that the use of representative and metaphorical images in a course on global warming for undergraduate students, mainly from social sciences, was associated with greater interest, commitment, emotional connection, and ability to understand problems and complex social processes than was the case with students unexposed to those images. Pate and Posey (2016) also found that the use of slides based on the precepts of multimedia learning theory helped to retain information and increased student satisfaction. Based on these and other studies, Grech (2018) summarized some recommendations for using this theory in the design of PowerPoint presentations for teaching medicine, which can be synthesized in three key principles: brevity, cogency, and clarity.

In a recent study (Smith-Peavler et al., 2019) that compared image-only presentations and combined image-text presentations to biology students, the authors found that image-only presentations had a positive impact on students' academic performance. Similarly, Cladellas and Castelló (2017) found that the text-only format did not contribute to a better academic performance with a sample of medical students. On the other hand, Johnson and Christensen (2011) found no differences in the performance of psychology students exposed to combined text-image presentations and text-only presentations. This suggests that design, by itself, is not a sufficient variable to predict the pedagogical usefulness of a presentation. In fact, Smith-Peavler and his colleagues (2019) acknowledged that "biology heavily relies on visualizations to communicate the complex interactions of biological systems across a wide range of scales" (p.74), so the reason why they chose an image-based approach for their presentations was purely epistemological and based on the specific features of their discipline, rather than the theoretical advantages of visual over textual slide design.

3.2.2. Teaching Practices

Williams and colleagues (Cullen, Williams, & McCarley, 2018; Williams, McCarley, Sharpe, & Johnson, 2017) agreed that PowerPoint has no pedagogical effect in itself and that it can lead to positive or negative results depending on other factors that may have an impact. One such factor that has been widely debated is the practice of giving students access to copies of the presentations, either printed or online. Kim (2018) found that students without previous access to the slides achieved better performance, probably because they were more anxious about not having a physical backup of the information delivered, so they paid more attention to the instructor's verbal explanations and information. This association between student's performance and the access to the slides is consistent with the studies of Worthington and Levasseur

(2015), who found that online access to the slides of the course, whether in full or partial format, did not affect attendance although it did relate to poorer student performance. Zdaniuk, Gruman, and Cassidy (2017) found that access to slides may have a positive effect upon students with high academic self-efficacy; but it reinforced students with low academic self-efficacy in their tendency to be passive, that is, not to take notes during the class and not to actively process the information delivered.

Certainly, access is not the only relevant factor. Smith-Peavler and his colleagues (2019) emphasized the importance of images for the study of biological disciplines, and Hallewell and Lackovic (2017) noted that the images used in psychology classes were mostly symbolic; but professors failed to use cues to help students identify their practical relevance in relation to the verbal content of the class, which may limit its pedagogical impact. This apparent inconsistency between image and content is significant, considering that Bartsch and Cobern (2003) showed, in their widely cited study on PowerPoint, that images unrelated to content generated interference in learning. If the students do not have clues that allow them to identify the relationship between image and content, it is possible that there is a counterproductive effect which may interfere with the learning process instead of supporting it.

Despite these conflicting results, there is some evidence that the use of technologies such as PowerPoint in the classroom is popular among students; and it impacts directly the perception they have about instructors (Ledbetter & Finn, 2018) although other researchers have suggested that instructors may overestimate the importance students place on PowerPoint (see James, Burke, & Hutchins, 2006). Nevertheless, students seem to be well aware of the problems related to the use of PowerPoint; and they openly criticize instructors’ tendency to overuse text-based slides, often directly copied from other sources, that are scrupulously read throughout the session (Yilmazel-Sahin, 2008).

This pattern of textual overload on the slides has been related to the concept of "academic boredom," which affects the academic performance of students (Sharp, Hemmings, Kay, Murphy, & Elliott, 2017).

3.2.3. Differences between Disciplines

Little is known about the differences in the pattern of use of PowerPoint in different disciplines although it is likely that there are important differences related to the predominant teaching approach in divergent areas. The use of images studied by Smith-Peavler and his colleagues (2019) in the area of biology and by Johnson and Christensen (2011) in the area of psychology point precisely in that direction. Similarly, Hertz, van Woerkum and Kerkhof (2015) reported that professors in medicine and physics consider the use of images to be indispensable because of the epistemology of their respective disciplines. In a study with students in four quite different areas, Kahramana, Çevika, & Kodan (2011) found that engineering students had a less favourable attitude towards PowerPoint than did students in economics, education, or vocational school. However, the authors only considered the perception of the students. In one of the few studies that directly addressed the issue, comparing "hard" disciplines (usually from the areas of natural science) with "soft" disciplines (social sciences and humanities), Garrett (2016) found that the hard disciplines tended to find PowerPoint more effective, but used less text and more images in their presentations than did the soft disciplines.

3.3. The Study

3.3.1. Participants

We contacted 403 full-time faculty members from 12 undergraduate programs at two prestigious universities of the autonomous community of Catalonia, Spain. Using a convenience sampling method, each respondent was contacted individually during the year 2018, either personally or by email, and asked to answer a paper-based survey. During the data collection process, a significant number of faculty members from mathematics departments said they were unable to participate because they did not use PowerPoint in their classes. The final sample included 106 surveys for an overall response rate of 26.3%.

Fifty-three percent of the sample were men, with an average age of 51.8 years (SD = 9.44) and an average time teaching at university level of 23.8 years (SD = 9.81). The majority of the sample came from programs related to the social sciences (39.6%), followed by natural sciences (31.1%) and medical sciences (29.2%). Specifically, the disciplinary areas included in this study were as follows.

- Social sciences: sociology (n = 8), economics (n = 2), psychology (n = 20), education (n = 6), and law (n = 6);
- Medical sciences: medicine (n = 17), pharmacy (n = 10), and physiotherapy (n = 4);
- Natural sciences: physics (n = 3), chemistry (n = 19), mathematics (n = 10), and biology (n = 1).

We did not look for a representative sample from each discipline; rather we actively sought to maximize the heterogeneity in the macrodisciplines we had identified. The humanities and engineering macrodisciplines were intentionally set aside because they present epistemic paradigms different from those of the scientific macrodisciplines.

3.3.2. Instrument

For this study we designed a survey specific to our purpose. A first version of this survey was pilot-tested with 10 faculty members in order, to ensure that the items were readable and unambiguous; and we made some minor changes based upon their feedback. We analysed the data obtained with the final sample using the statistical software SPSS© v.24 for descriptive analyses and mean comparisons and tests of association.

The instrument consisted of four sections. The first section collected general demographic data (i.e., gender, age, years of experience, discipline). These variables were used to describe the sample and then to categorize the respondents according to the disciplinary categories of the Organisation for Economic Co-operation and Development (natural sciences, medical sciences, and social sciences), which were used as a comparison variable in subsequent analyses.

In the second section respondents described their PowerPoint usage patterns, for example, whether or not PowerPoint slides were uploaded to online platforms and when (before each session, after each session, or both). In addition, faculty members had to choose the main purpose they had for using PowerPoint, with four predefined options offered: "to study for the exams,” "to critically reflect on the contents of the course,” "to memorize key concepts of the course," and "to illustrate the contents of the course". It is important to note that this study focused solely on the perceptions of the instructors. Therefore, when we speak of rote learning or critical reflection in the following sections, we only refer to what the instructors thought was the main purpose of their PowerPoint presentations. This opinion may or may not be consistent with the perceptions of their students.

The third section was composed of a seven-point Likert scale, coded from 0 to 6, and based on the revised Unified Theory of Acceptance and Use of Technology model (UTAUT-2; Venkatesh, Thong, & Xu, 2012). Indeed, the use of any given technology relies upon a series of underlying factors that allow us to understand why we accept some technologies in different contexts, including academic ones, while others cannot be successfully integrated. UTAUT-2 is currently one of the best models to predict this use. In our study usage of this model involved eight factors for using PowerPoint in educational contexts:

i) Performance expectancy, defined as individual beliefs about the benefits in job performance when using PowerPoint;

ii) Effort expectancy, which refers to beliefs regarding the effort required to use PowerPoint;

iii) Facilitating conditions, which refers to the belief that the institution has the necessary infrastructure to support appropriate use of PowerPoint;

iv) Social influence, which refers to the extent to which an individual perceives that significant others (colleagues, friends or family members) believe that he or she should use PowerPoint;

v) Hedonic motivation, defined as the pleasure obtained from using PowerPoint;

vi) Habit, which refers to the automatism or dependence on using PowerPoint;

vii) Attitude towards PowerPoint; and

viii) Intention to use PowerPoint, which refers to the willingness of the individual to make use of this technology in the future.

Some examples of the items are: "PowerPoint is a useful tool for teaching my classes," "PowerPoint is easy to use," "Most of my colleagues use PowerPoint," "I enjoy using PowerPoint in my classes," and "I can't conceive of teaching without using PowerPoint."

The results of a confirmatory factor analysis of this section indicated that the adapted version of UTAUT-2 was suitable to use in this academic context, with values of composite reliability that ranged between .68 and .92, and average variance extracted superior in all cases to .50. The composite reliability and average variance extracted from each scale and the correlation matrix of the model variables are detailed in Table 3.1. The fit indices in general were adequate, with the following values: χ^2/df = 1.74; CFI = .95; TLI = .95; RMSEA = .08; SRMR = .06.

Table 3.1. Convergent and discriminant validity of the confirmatory factor analysis

		CR	AVE	1	2	3	4	5	6	7
Performance Expectancy	1	.826	.704	**.839**						
Effort Expectancy	2	.909	.770	.014	**.878**					
Social Influence	3	.801	.670	.632*	.069	**.818**				
Facilitating Conditions	4	.677	.521	-.075	.483*	.049	**.722**			
Hedonic Motivation	5	.781	.641	.708*	.103	.541*	.174	**.800**		
Habit	6	.877	.705	.684*	.053	.524*	-.101	.577*	**.839**	
Attitudes	7	.919	.792	.711*	.082	.494*	.089	.742*	.680*	**.890**

Note. CR = Composite Reliability; AVE = Average Variance Extracted. Bolded diagonal elements are the square root of AVE. These values should exceed inter-construct correlations (off-diagonal elements) for adequate discriminant validity.
*: Correlation is significant at the 0.01 level (two-tailed).

Finally, the fourth section inquired about the types of PowerPoint slides most used by the respondents. The slides were considered textual when texts and definitions were primary; visual when the format gave preference to images, graphics, or tables; auxiliary when using indices or headlines without additional explanatory text; and combined in the event that two or more of these categories were equally relevant.

3.4.Data Analysis and Results

3.4.1. Preliminary Analyses

In the preliminary analysis we observed through a one-way ANOVA that there were significant differences of age between the groups, F (2,103) = 6,584, p = .002, and teaching experience, F (2,103) = 12,088, p <.001. Specifically, faculty members from natural sciences were on average older and had more experience in teaching than did their peers in the medical and social sciences. We ruled out any distortion in the results due to gender biases using a chi-square test, and we found no significant difference in the distribution of gender by discipline although natural sciences had a greater distribution of men.

In addition to the demographic variables described above, we should also note that we had originally intended to evaluate the impact of uploading PowerPoint online. However, 86.8% of the sample reported uploading their presentations, which means that only 14 of the participants did not allow their students to access the material digitally, a sample to assess usage patterns associated with this variable. So this variable was not used in subsequent analyses. The characteristics of the sample, including this variable, are detailed in Table 3.2.

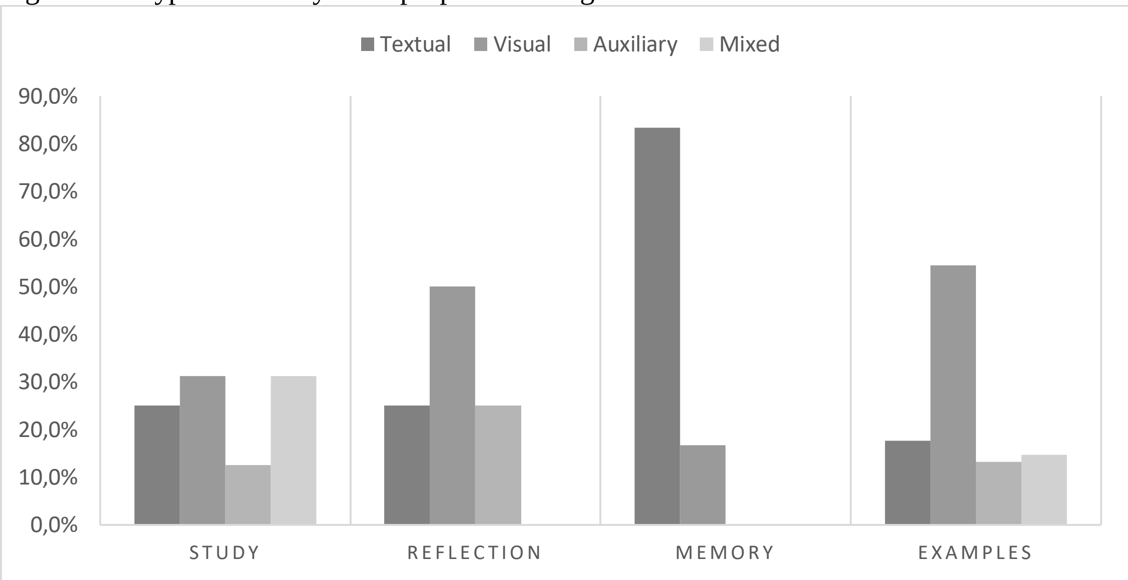
Table 3.2. Sample characteristics

	Natural (n=33)	Medical (n=31)	Social (n=42)
Gender (%)			
Male	63.6	45.2	52.4
Female	36.4	54.8	47.6
PowerPoint online (%)	81.8	93.5	85.7
Age (mean, SD)	56.18 (5.89)	51.29 (8.08)	48.64 (11.29)
Experience (mean, SD)	30.03 (6.23)	22.00 (9.57)	20.21 (10.12)

Note. SD = Standard Deviation.

Overall, respondents indicated that they used PowerPoint as follows: to illustrate the contents of the course (66.7%), to help students study for exams (15.7%), to reflect critically on content (11.8%), and to memorize key concepts (5.9%). The respondents reported using mainly visual (48.0%) and textual (23.5%) slides and. to a lesser extent, combined (14.7%) or auxiliary (13.7%) slides. We found significant associations between the main purpose and the type of slides reported, $\chi2 = 20.488$, $p = .015$. In particular, faculty members who believed that PowerPoint is especially useful to memorize key concepts used almost exclusively textual slides, while those who reported using PowerPoint to reflect or illustrate the content preferred visual slides. If the main purpose was identified as studying for exams, no precise pattern was observed although there is a relatively smaller use of auxiliary slides, which is the less informative type of slides (see Figure 3.1).

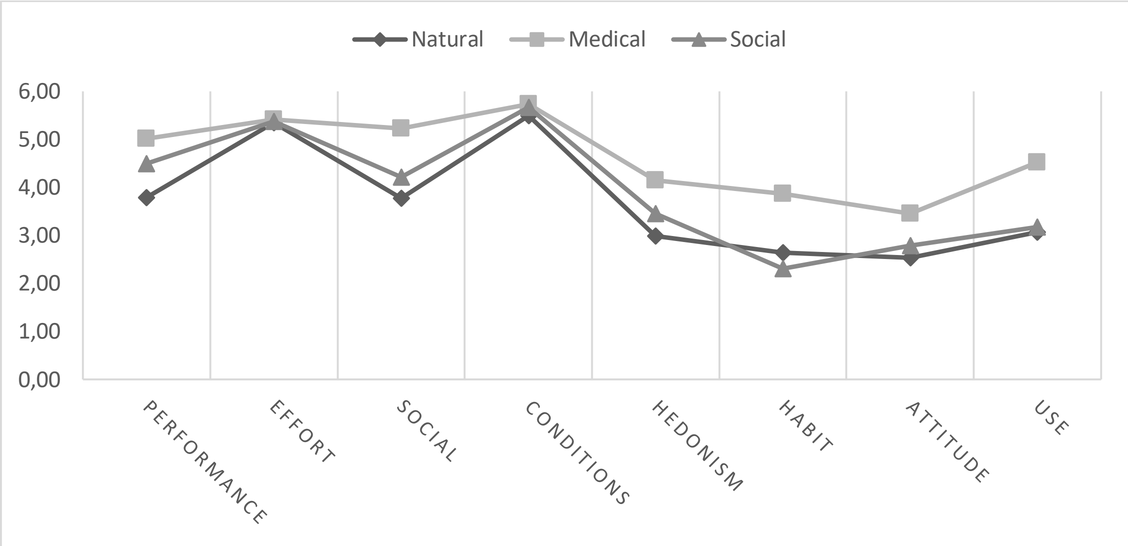
Figure 3.1. Type of slide by main purpose in using PowerPoint



3.4.2. Comparison by Disciplines

When analysing the dimensions of the adapted version of the unified theory of acceptance and use of technology (UTAUT-2), the scales of effort expectancy and facilitating conditions scored very high (mean > 5), indicating that faculty members thought that using PowerPoint is easy and that they have all the necessary infrastructure and support in their institutions to use it properly. Of course, this was expected given the ubiquitous implementation of PowerPoint and university policies aimed at increasing its use by instructors. In general, the medical sciences have higher averages on all the scales, while the natural sciences have the lowest averages. A similar pattern is observed in the three areas studied although there were some differences in the resulting means (see Figure 3.2). Performance expectancy and social influence were consistently the two most relevant of the eight UTAUT-2 dimensions in this study. There were more similarities between the natural and social sciences, while medical sciences tended to show a pattern different from the other disciplines. In particular, some remarkable differences were found in the scales of social influence, habit, and intention to use.

Figure 3.2. UTAUT-2 scales, by discipline



The statistical comparisons among the three areas of knowledge studied in the present investigation are detailed in Table 3.3.

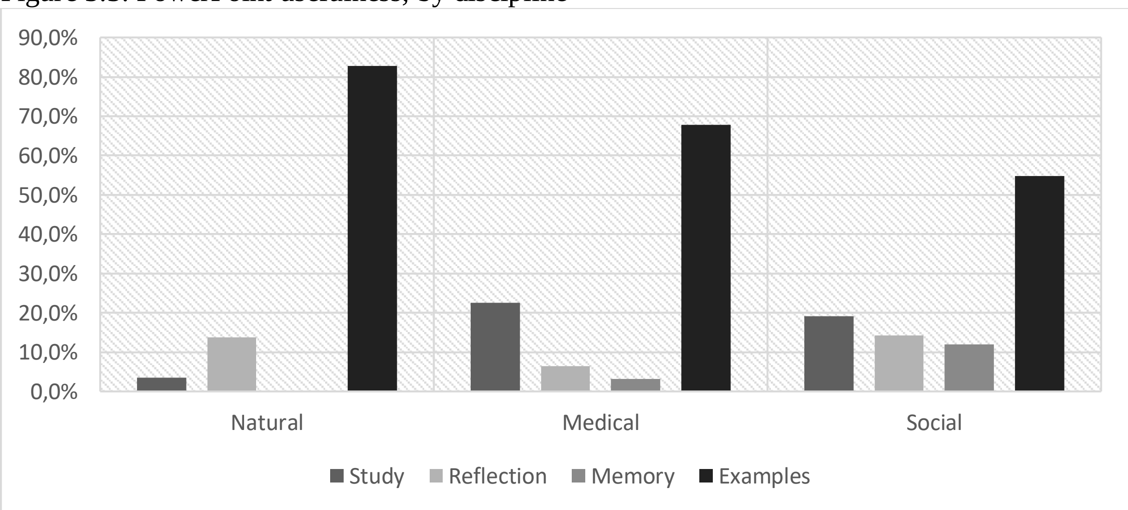
Table 3.3. Comparisons of variables, by discipline

	Natural (n=33)	Medical (n=31)	Social (n=42)	χ^2	Sig.
	Freq. (%)	Freq. (%)	Freq. (%)		
Type of slides *				19.717	.003
Textual	3 (10.3)	7 (22.6)	14 (33.3)		
Visual	20 (69.0)	18 (58.1)	11 (26.2)		
Auxiliary	1 (3.4)	2 (6.5)	11 (26.2)		
Mixed	5 (17.2)	4 (12.9)	6 (14.3)		
PowerPoint main purpose *				11.775	.067
Study	1 (3.4)	7 (22.6)	8 (19.0)		
Reflection	4 (13.8)	2 (6.5)	6 (14.3)		
Memory	-	1 (3.2)	5 (11.9)		
Examples	24 (82.8)	21 (67.7)	23 (54.8)		
	Mean (SD)	Mean (SD)	Mean (SD)	F	Sig.
Performance expectancy	3.79 (1.62)	5.02 (.71)	4.49 (.95)	9.238	.000
Effort expectancy	5.34 (.59)	5.41 (.42)	5.37 (.74)	.094	.911
Social influence	3.77 (1.60)	5.23 (.59)	4.21 (.94)	14.166	.000
Facilitating conditions	5.48 (.66)	5.73 (.40)	5.67 (.50)	1.839	.164
Hedonic motivation	2.98 (1.34)	4.15 (1.01)	3.45 (1.11)	8.043	.001
Habit	2.64 (1.95)	3.86 (1.35)	2.31 (1.59)	8.325	.000
Attitude	2.54 (1.41)	3.45 (1.02)	2.79 (1.19)	4.852	.010
Intention to use	3.06 (2.22)	4.52 (1.18)	3.17 (1.51)	7.539	.001

Note. * In the case of the usefulness of PowerPoint and the type of slides, four faculty members from the area of natural sciences did not complete their answers, therefore n = 29.

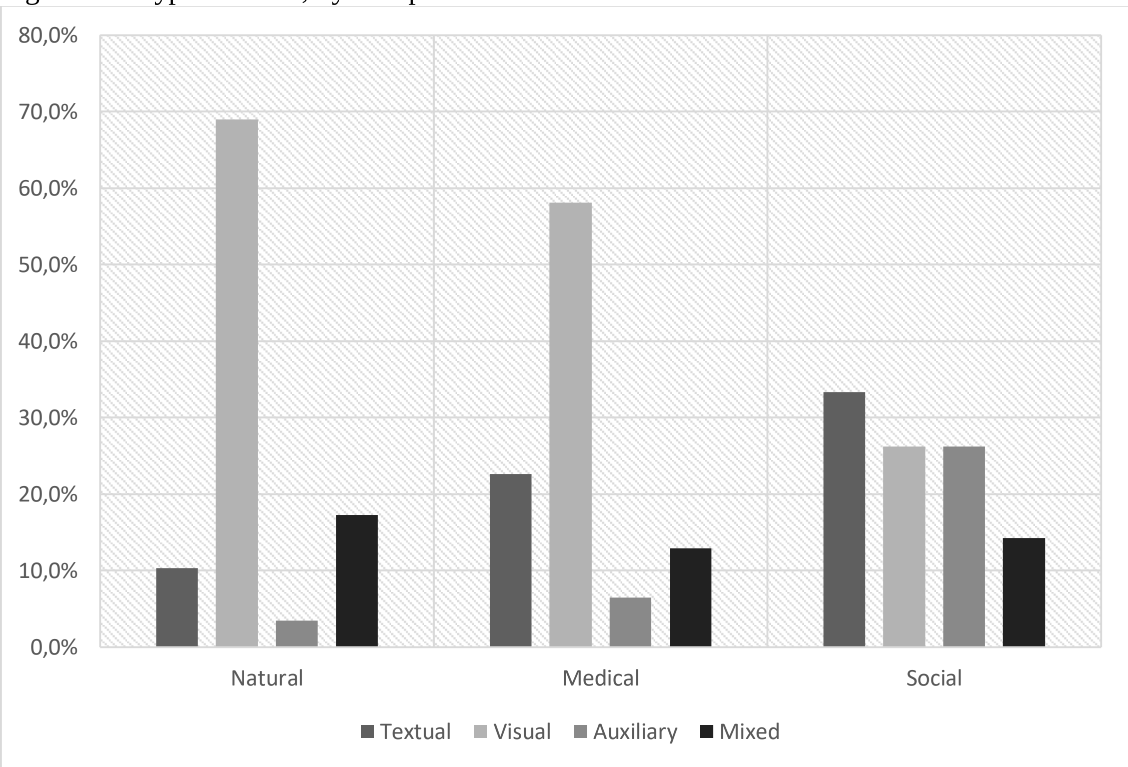
Some interesting differences emerged from the comparison of the perceived usefulness of PowerPoint and the type of slides used in each group, which were significant using a chi-squared test, $\chi 2 = 19.717$, $p = .003$. In all areas faculty members reported that their main purpose was to illustrate the course content. However, in the natural sciences critical reflection upon course content (13.8%) also showed some relevance; but in both the medical and social sciences the second most important purpose identified was to study for exams (22.6% and 19.0%, respectively). Although social science instructors also recognized the importance of critical reflection (14.3%) even more than did natural sciences instructors, it only represents the third most frequently chosen option. Memorizing course content was of relatively minor importance in the social sciences (11.9%), and it was of minimal importance in the medical sciences (3.2%). It was not even mentioned in the natural sciences (0.0%). Figure 3.3 illustrates faculty members' perceptions of the usefulness of PowerPoint in the three macrodisciplines.

Figure 3.3. PowerPoint usefulness, by discipline



Similar differences were observed with the type of slides used (see Figure 3.4), despite the fact that a chi-square test did not find significant associations between the disciplinary area and this variable, $\chi 2 = 11.775$, $p = .067$. While the natural and medical sciences are predominantly visual (69.0% and 58.1%, respectively), the social sciences showed a more balanced tendency among the four types of slides studied, with a slight preference for the textual type (33.3%). It is interesting to note that, when comparing the natural, medical and social sciences, in that order, a decreasing pattern of image use and an increasing pattern of textual slides were simultaneously observed.

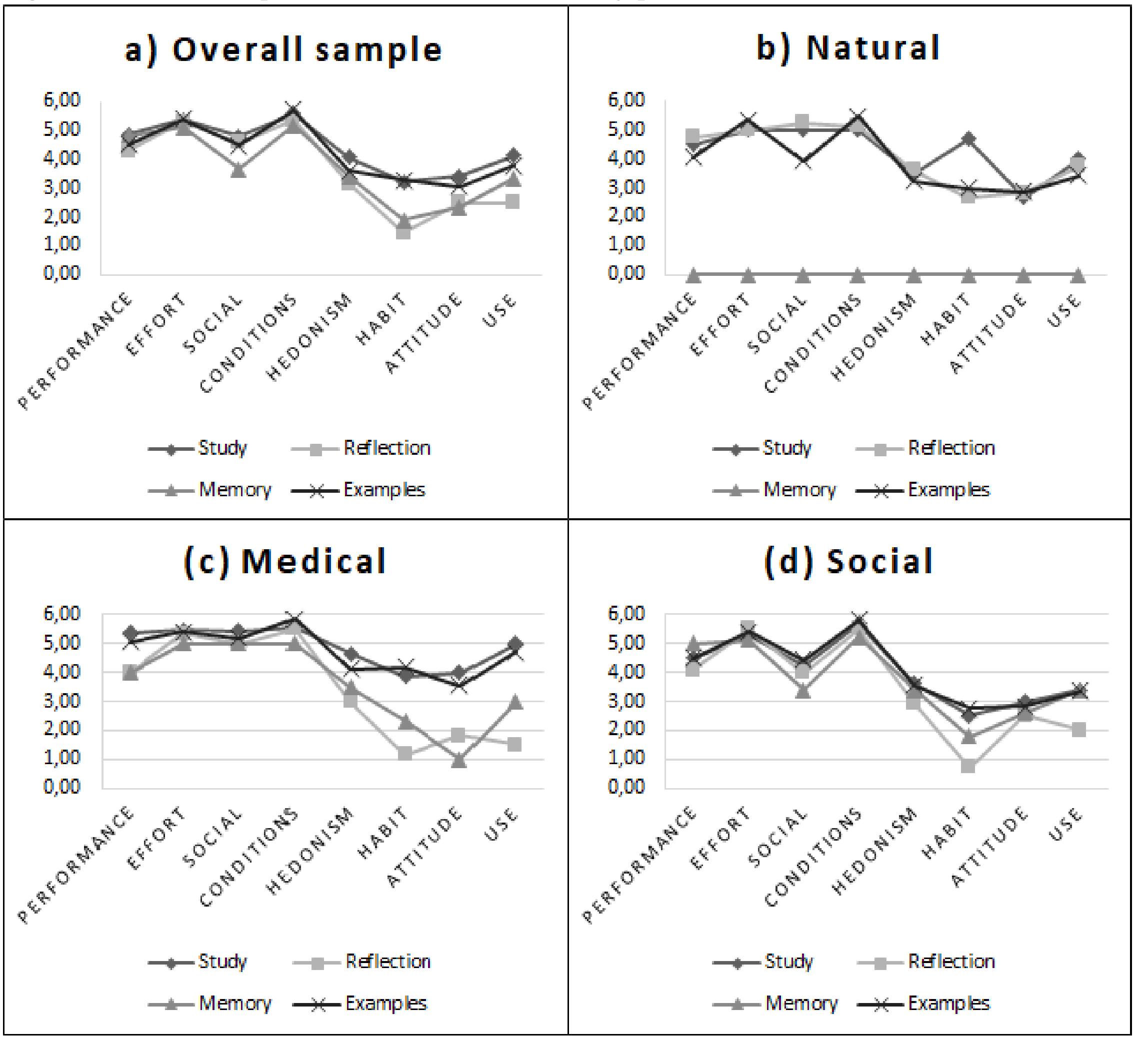
Figure 3.4. Type of slides, by discipline



We found a relationship between the habit scale and the reported purpose for using PowerPoint. As seen in Figure 3.5, low scores on this scale were related to a perception that the main purpose of PowerPoint was to reflect on content or to memorize key concepts. Inversely, higher scores on the habit scale were related to the use of PowerPoint as study material for students or to illustrate content. This was true in the general sample and in all the sub-samples. The only exception was found in the natural sciences group within which the use of PowerPoint to illustrate content had a pattern similar to critical reflection. These differences were tested using a one-way ANOVA, which revealed that habit averages vary significantly in the general sample, $F(3,98)$ =

5,598, p = .001 and in the medical, F(3,27) = 4.822, p = .008, and social sciences, F (3.38) = 3.315, p = .030. In the case of natural science instructors, the difference was not significant, F (2.26) = .481, p = .624. However, the differences remained noticeable. No other UTAUT-2 scale showed a stable pattern across all the disciplines studied in this research.

Figure 3.5. Mean comparison in UTAUT-2 scales, by perceived usefulness



Only in the case of medical sciences did these differences extend to factors such as performance expectancy, F (3,27) = 3,129, p = .042, attitude, F (3,27) = 6,953, p = .001, and intention to use, F (3,27) = 10,998, p = .000. This is an interesting finding, because, as we will see in Chapter 4 and 5, this is the 'rational' path to use PowerPoint.

3.5.Discussion

According to widely used theories regarding the use of PowerPoint in educational contexts, such as multimedia learning theory, the best way to improve the effectiveness of PowerPoint presentations is to use a combination of images and voice or images and texts (Roberts, 2018a). In our study significant differences emerged both in the factors for using PowerPoint, as measured by the UTAUT-2 scales, and in the type of slides predominant in the three macrodisciplines studied. As expected (H1), there was a high predominance of visual or combined presentations in the natural and medical sciences, while the social sciences were still dominated by textual slides, which could limit their effectiveness in learning. Indeed, as stated in H2, the use of textual slides was associated with a purpose based on rote learning. These results (H1-H2) are consistent with the findings of previous research (Smith-Peavler et al., 2019; Hertz, van Woerkum and Kerkhof, 2015), which showed that the natural and medical science disciplines were more focused on images because of the nature of the disciplinary content. Conversely, Johnson and Christensen (2011) did not find any effect of the type of slides on psychology students' performance. However, their design simply converted text-based slides into visually-rich slides. The pedagogical value of the content of each slide was not called into question. In fact, when looking at the examples they presented in their study, the slides are clearly intended to define key concepts so that just transferring a text-only slide to a visually-rich slide, although probably more attractive to students, did not necessarily increase the pedagogical value. In Roberts' studies (2018a; 2018b), specially designed images were used to foster critical reflection, which obtained positive results. Perhaps the incongruence between the type of slides and their reported purpose partly explains the ambiguous results of previous research about PowerPoint effectiveness.

A second observation derived from our findings is that programs related to medical sciences have their own pattern of factors for using PowerPoint, while both natural sciences and social sciences share a more similar pattern. Although a specific pattern of factors for using PowerPoint was expected in the three groups (H3), only the medical sciences instructors had a more positive outlook regarding the expected benefits associated with the use of PowerPoint. They also showed greater dependence and automatism in this use. It is possible that this positive but dependent combination explains in part why this discipline gives less importance to critical reflection through PowerPoint. Perhaps the decision to use PowerPoint to stimulate critical reflection upon content requires a critical stance towards the technological tools used to present the content.

We also observed that high scores on the habit scale, defined as the level of dependence upon the use of PowerPoint in the classroom, are strongly related to the use of PowerPoint to study for exams, while low scores on this scale are related to the use of PowerPoint for critical reflection. This pattern remains stable in the three areas of knowledge evaluated. This is particularly interesting because, as far as we have been able to discern, this relationship had not been studied in previous research.

3.5.1. Implications

We believe that our study has implications on a theoretical and practical level. At the theoretical level there are few studies that have directly compared the use of PowerPoint in different areas of knowledge. This research aimed to gain further insight into the factors that influence its use and the different patterns of use of PowerPoint in the macrodisciplines of the medical, natural, and social sciences. Additionally, we added some factors for using PowerPoint, as measured by the UTAUT-2 dimensions, revealing the significant role habit is playing in all three disciplines. Finally, we postulated that the incongruence between the type of slides and their reported pedagogical value could explain some of the inconsistencies found in the effectiveness of PowerPoint in past research.

On a practical level, some differentiated profiles have been established in the use of PowerPoint, which can encourage the design of specific strategies by discipline. This is particularly worthwhile because this research emphasizes what type of slides are usually associated with a specific function, which opens the way to new interventions and investigations to understand the importance of the design of the slides being consistent with faculty members' pedagogical approach.

It is clear from this study that there are specific patterns of PowerPoint use, depending on disciplinary content. This finding has important implications: if the social sciences, due to the epistemology of these disciplines, use more textual slides, which are associated with rote learning, it becomes important to foster a more thoughtful use of PowerPoint. For example, instructors might be encouraged to think about how it can best be designed to enhance learning.

Finally, a higher dependence on the use of PowerPoint for lectures, as evaluated with the habit scale in this study, is associated with using PowerPoint to study for exams. Of course, this means that PowerPoint goes from being a support tool for teaching, to simply helping students to pass their exams. This finding is fundamental and calls for developing strategies that help faculty members in the support of innovation and critical use of educational technologies such as PowerPoint, which is more than simply implementing policies to encourage its use. Instructors who use PowerPoint in a way that we have called "critical use," with low scores on the habit scale, often report that they use PowerPoint to encourage students to reflect critically upon content. Developing strategies for this type of use should be a priority in all higher education institutions in order to exploit the pedagogical potential of PowerPoint.

3.5.2. Limitations and Future Research

As in any study, there are some limitations that must be mentioned. First, the sample is relatively small. Although it is not uncommon in such research to have a sample of similar size, we suggest replication of this study with a larger number of faculty members before generalizing its results. Additionally, an expanded sample would allow observing the differences in PowerPoint usage patterns between different majors within a particular macrodiscipline (e.g., psychology and sociology in social sciences; biology and physics in natural sciences; medicine and nursing in medical sciences).

Second, we used only self-reports of the faculty members, so it is possible that the results are biased. The original design of this study included the use of actual slides as provided by respondents in order to obtain an objective measure. However, because of logistical problems we were unable to do so. Combining that kind of objective measure in a future study would allow evaluation of the existence of bias with respect to the type of slides used by comparing the perception of the faculty members with an objective analysis of the slides they actually used.

In this study, faculty members who claimed to use PowerPoint primarily to help students memorize key concepts also claimed to use mainly textual slides. This association between textual slides and rote learning is particularly interesting since criticism of the use of PowerPoint refers precisely to the fact that it has been dominated by a text-centric trend, whereas in this study only 24% of the instructors indicated that they preferred using textual slides. Is it possible that faculty members underestimate their use of textual slides, thereby favouring a more rote-based learning than they might think they are doing.

3.6.Conclusion

This study revealed patterns in faculty members' use of PowerPoint in the macrodisciplinary areas of natural, medical, and social sciences. Previous research has generally focused on the effectiveness of PowerPoint or the attitude of students towards its use. We still know very little about how and why this technological tool is used in academic contexts. In our sample the results suggest that some underlying factors, especially habit, may play a relevant role in the PowerPoint usage pattern. While we know that the text-image combination seems to be better for critical learning, it is not very clear if this combination works equally well in all contexts. We believe that it is important to investigate these issues in greater detail, to understand how and why it is used, and to continue to assess its effectiveness. In the words of Roberts (2018a), "[t]here is a very sound pedagogic rationale for this conceptual breach to be found in our understanding of cognitive loading, which for some leading scholars means that how we often use PowerPoint may be substantially counter-productive, pedagogically" (p. 15).

CAPITULO 4: ¿POR QUÉ USAMOS POWERPOINT EN EDUCACIÓN SUPERIOR?

4.1.Introduction

In the last three decades, the use of information technologies (IT) as teaching support tools has become an ubiquitous element in classrooms. Arguably, the inclusion of these technologies is one of the most relevant changes in education with presentation programmes (e.g. Microsoft PowerPoint©) playing a key role due to their wide adoption. More than a decade ago, Microsoft estimated that between 20 and 30 million PowerPoint-based presentations were given each day, being its primary context of usage the business world but slowly becoming entrenched in the academy (Levasseur & Sawyer, 2006).

However, although no one doubts the fast growth in the use of these technologies in educational contexts (Johnson & Christensen, 2011; Kinchin, Chadha, & Kokotailo, 2008), relatively little is known about their pedagogical effectiveness (Craig & Amernic, 2006), and even less on the way in which it has been implemented in higher education. Despite authors providing critical evaluation on the use of PowerPoint in universities (see, for example, Adams, 2006; Rose, 2004), its use tend to be accepted without too many questions. While in more traditional organizational contexts (i.e., the business world), the mechanisms underlying the implementation of technologies are studied extensively (see Benbasat & Barki, 2007), this phenomenon has not been a relevant issue in educational research agendas.

4.2.Literature review

There is an extensive literature regarding the use of presentation programmes in educational contexts, but in general, these studies have focused on two main trends. On the one hand, studies aimed at enhancing the effectiveness of the use of technologies in the classroom. Authors such as Craig and Amernic (2006) were surprised more than a decade ago by the lack of authoritative studies regarding the effectiveness of PowerPoint, despite its widespread use, and noted that the evidence of learning benefits was rather inconsistent. Although in recent years, these studies have been increasing, the results are still unclear (Baker et al., 2018). Bartsch and Cobern (2003) pointed out that, although visual content was thought to help students memorize content, there was no increase in performance associated with the use of PowerPoint. In the same vein, Johnson and Christensen (2011) found no differences in student performance using traditional text-based presentations or simplified but visually rich-based presentations. In a recent study, Garrett (2016) stated that the "*majority of these studies showed that PowerPoint had not statistically significant impact on student learning*" (p. 366). Some authors (e.g., Cladellas & Castelló, 2017) suggest that the problem may lie in two concurrent elements: first, PowerPoint's relatively rigid linear structure limits the possibilities of teacher-student interactions; and second, the written information competes with the verbal information of the teacher, so that the students end up focusing on the written content, and fail to focus on the usually more relevant verbal content. Roberts (2018a) goes to say that "*the academy remains wedded to an eccentric text-centricity quite at odds with the world beyond the ivory silo*" (p. 15), which can partly explain the lack of effectiveness found in many studies on PowerPoint. This does not necessarily mean that PowerPoint is not a useful educational technology; rather, it implies that its usefulness is not uniform for all areas and for all type of contents (Garrett, 2016).

On the other hand, research focused on the perceptions of students regarding the use of PowerPoint. Moulton, Türkay and Mosslyn (2017) identified 26 studies on this topic, and 21 of them found that students prefer PowerPoint over traditional blackboard and chalk instruction. Indeed, studies tend to show that the use of PowerPoint by teachers increases their prestige and credibility among students (Garrett, 2016; Ledbetter & Finn, 2018). However, the excessive use of PowerPoint by academics, and their lack of expertise in using it, has been identified as one of the main causes of “academic boredom” by undergraduate students (Sharp, Hemmings, Kay, Murphy, & Elliott, 2017), pointing out that professors repeat almost verbatim the content of slides, that slide presentations are usually very extensive and loaded with text-based content, or that the teacher stops interacting with their students during their presentations, focusing his/her attention to the slides.

In more recent years, both lines of research have been integrated, relating good pedagogical practices with the perceptions of students (e.g., Cladellas & Castelló, 2017). However, as interesting and relevant that studying the real impact of PowerPoint in educational contexts might be, these two lines of research do not seem to answer a more basic question: given the limited evidence in favour of the pedagogical benefits associated with the use of PowerPoint, why do teachers keep using it?

The most obvious answer is that its use has become so widespread that it has simply been adopted as another element of the classrooms. This is usually known as the acceptance and adoption of technological tools, such as PowerPoint, an area of study with a long tradition in other disciplines, especially in the area of information management (Davis, 1989), but still underused in the area of education. One of the best-known branches is based on the theories of reasoned action (TRA) and planned behaviour (TPB), which have given rise to various models of technology acceptance, such as the Technology Acceptance Model (TAM; Davis, Bagozzi, & Warshaw, 1989), the Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh, Morris, Davis, & Davis, 2003), and its revised version, the UTAUT2 (Venkatesh, Thong, & Xu, 2012).

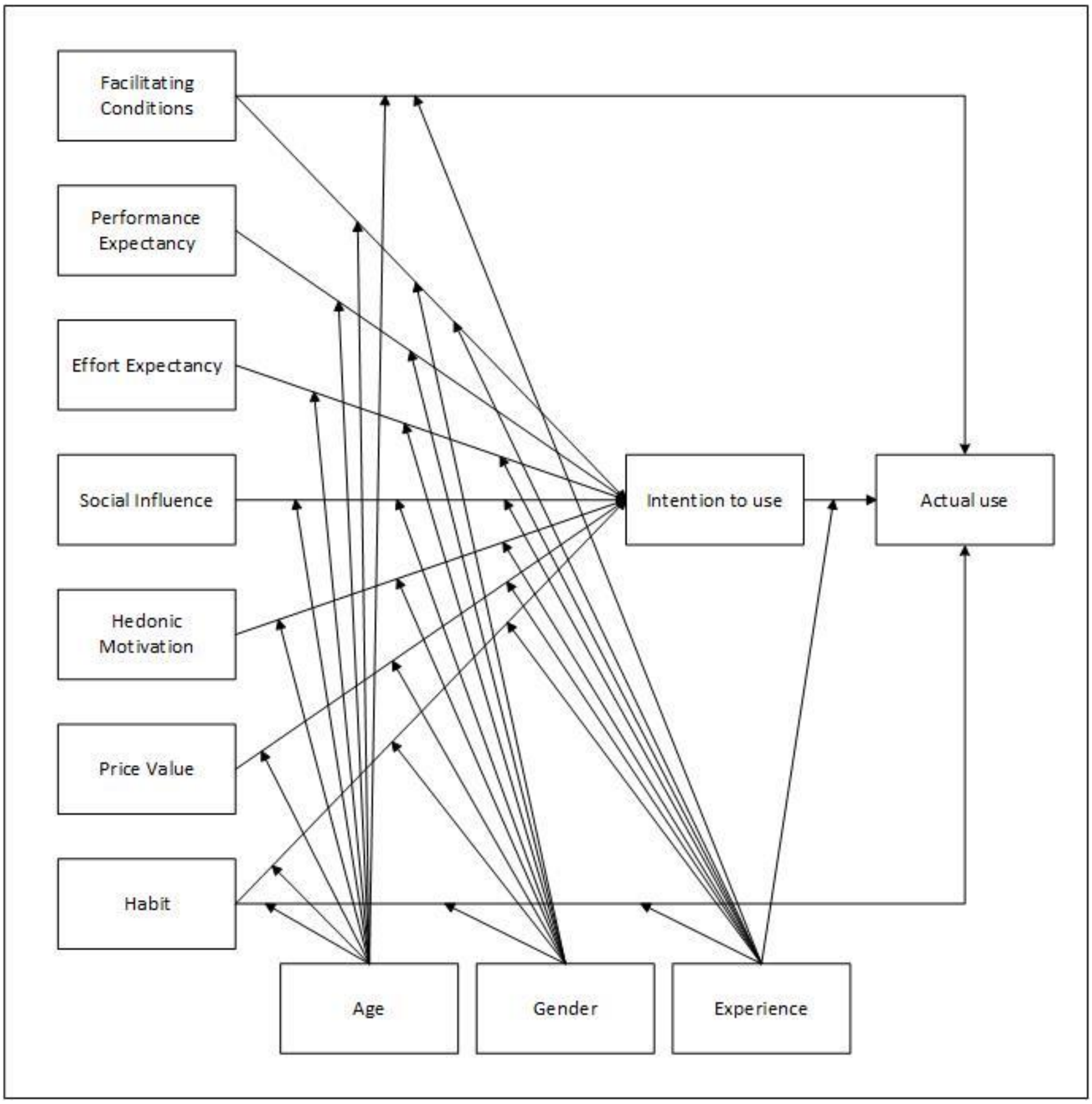
4.2.1. UTAUT and UTAUT2

The UTAUT is based on eight previous theoretical models, including the TAM, TRA and TPB (Venkatesh, Morris, Davis, & Davis, 2003), and reduces them into four main variables that explain intention to use (IU) and actual use (AU). These variables are performance expectancy (PE) and effort expectancy (EE), facilitating conditions (FC) and social influence (SI).

The UTAUT2 (Fig. 4.1) is an extension of the previous model, which includes three new variables: i) hedonic motivation, referring to the fun an individual experiences when using a certain technology, and that influences both IU and AU; ii) price value, a construct derived from a user perspective as a consumer of technology, and which therefore assesses whether the benefit of using a given technology exceeds its monetary value; and iii) habit, a way to operationalize past experiences, but transcending simple experience, adding some form of automatism or dependence to the behaviour of using technology (Venkatesh, Thong, & Xu, 2012).

As these are relatively recent models, their use in educational contexts is still rather unusual. For example, Šumak and Šorgo (2016) assessed the adoption of interactive whiteboards among teachers in Slovenia by adapting the UTAUT to the educational context, taking up the variable “attitude” of the TAM and adding the variable “experience in teaching” as a moderator. The authors concluded that this model can be adapted and applied in educational contexts. In the few studies that use the UTAUT2 in educational contexts, the variable "price value" is usually taken out (Ain, Kaur, & Waheed, 2016).

Figure 4.1. UTAUT2 model (based on Venkatesh, Thong, & Xu, 2012)

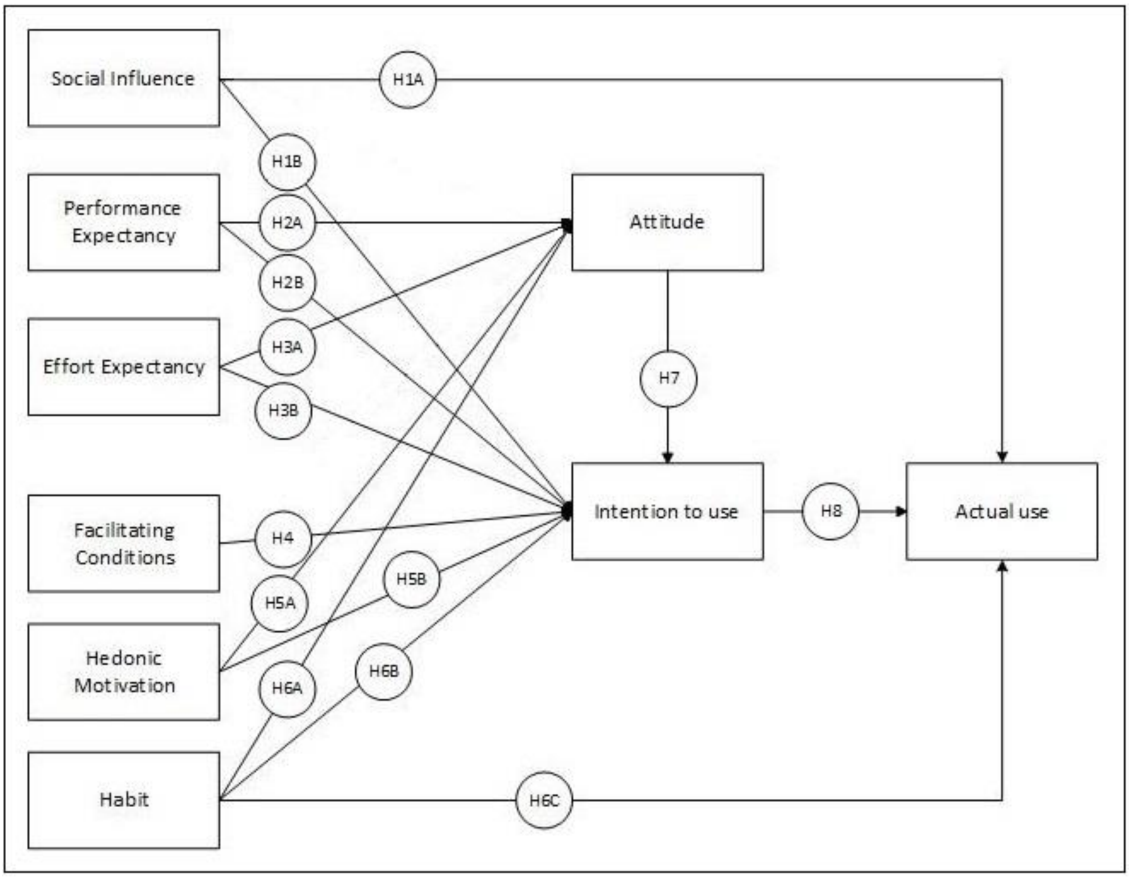


4.3.Research model and hypotheses

Although the UTAUT is a robust model, it has been tested mainly in information management systems (Benbasat & Barki, 2007). Therefore, it is necessary to adapt it to the educational context. In this case, we build upon the UTAUT2 model (Venkatesh, Thong, & Xu, 2012), with some modifications. It should be noted that we have chosen to discard the variable "price value". Although in their study, Ain, Kaur and Waheed

(2016) advocate replacing it with the concept of "learning value", this conceptual innovation is based on the perception of students regarding the relationship between time and effort invested in a system and the benefits obtained from this use. However, in the case of teachers, this value is too close to PE, so it has not been considered in this particular model.

Figure 4.2. Research model



The research model includes the attitude towards the action of using PowerPoint, so it is not an attitude toward PowerPoint itself. Figure 4.2 shows the research model with each path and its associated hypotheses. It should be noted that, for greater clarity, and to highlight the hypotheses of this study, Figure 4.2 does not include age, gender and experience using PowerPoint, considered as moderators in this model, and to be tested in each of the paths.

4.3.1. Social Influence

Social influence (SI) refers to the extent to which an individual perceives that significant others (i.e., colleagues, friends or family members) believe that they should use PowerPoint. In the original model, SI only predicts behavioural intention (BI). However, we are not assessing the acceptance and adoption of a new technology as measured by the original version of UTAUT and UTAUT2, but the continued use of an old technology. In this context, it is possible that SI has a direct impact on the decision to continue using this technology, a novel hypothesis that has not been tested before in UTAUT2, although Manning (2009) did found a direct effect of two forms of SI on behaviour using TPB. Finally, it has been widely demonstrated that SI is unrelated to ATT, so a direct relationship between both variables is not hypothesized:

H1A: SI will have a significant influence on AU.

H1B: SI will have a significant influence on IU.

4.3.2. Performance Expectancy

PE refers to the belief about the benefits in job performance when using a certain technology, in this case, PowerPoint. Although in the UTAUT2, PE directly affects IU, in the TAM (Davis, Bagozzi, & Warshaw, 1989), ATT mediated the relationship between PE/PU and IU. More recently, Šumak and Šorgo (2016) found a direct relationship between PU and ATT. Based on this, it is expected that:

H2A: PE will have a significant influence on ATT.

H2B: PE will have a significant influence on the IU.

4.3.3. Effort Expectancy

EE refers to the beliefs regarding the effort required to use a certain technology. In this study, EE is expected to be related to both ATT and IU.

H3A: EE will have a significant influence on ATT.

H3B: EE will have a significant influence on IU.

4.3.4. Facilitating Conditions

Although FC is related to both IU and AU in UTAUT2, the rationale behind these relationships is based on the assumption that the acceptance of new technology is being evaluated. In the case of PowerPoint, it is a relatively old and widely disseminated technology, so it is doubtful that infrastructure is a relevant factor for its use. This idea is strengthened by the study of Gellerstedt, Babaheidari, and Svensson (2018), who found no relationship between FC and AU when using a variation of the UTAUT to evaluate teachers' adoption of ICT pedagogy in schools. Therefore, the direct relationship between FC and AU has been eliminated from the research model.

H4: FC will have a significant influence on IU.

4.3.5. Hedonic Motivation

The pleasure gained from using a technology is related to the intention to use it. Until now, HM had not been used together with ATT in UTAUT2, however, Brännback, Nikou, and Bouwman (2017) found that hedonism also affected the attitude towards the interactive use of social media. So:

H5A: HM will have a significant influence on ATT

H5B: HM will have a significant influence on IU.

4.3.6. Habit

One of the most interesting variables introduced by UTAUT2 is HA. Before UTAUT2, Limayem, Hirt, and Cheung (2007) already proposed that, in the case of the continued use of a technology, habit was an important variable, which limited the impact of IU on AU. Indeed, these authors pointed out that, once the behaviour started, it is often automated in the user, so that the intention to use decreases with time and the habit of use increases. Similarly, Guinea and Markus (2009) reasoned that as intentional behaviour becomes habitual, it no longer requires a conscious intention to be activated, so that measures of explicit use intention lose value. Precisely because HA is understood as a mechanism of unconscious repetition of behaviour, it is not expected that it will be related to direct constructs, such as the explicit attitude towards the use of PowerPoint (ATT) or the conscious intention to use it. As this variable is of particular interest, the three possible paths in this model will be tested anyway.

H6A: HA will not have a significant influence on ATT

H6B: HA will not have a significant influence on IU.

H6C: HA will have a significant influence on AU.

4.3.7. Intention to use

The intention to use PowerPoint refers to the willingness of the individual to make use of this technology in the classroom. As predicted by UTAUT2, it is hypothesized that this variable directly predicts AU. Additionally, based on the TAM, it will be assumed that ATT has a direct impact on IU. Thus:

H7: ATT Will have a significant influence on IU.

H8: IU will have a significant influence on AU.

4.4. Method

4.4.1. Participants and data collection

The participants in this study were 106 college teachers from two universities of the autonomous community of Catalonia, Spain. The participants were contacted individually by one of the researcher, using a convenience sampling procedure in 12 undergraduate programs from different areas of knowledge from March to December 2018, and were asked to take part voluntarily in a study on the use of PowerPoint in higher education. Fifty three percent of participants were men, and the average age of all participants was 51.8 years (SD = 9.44), with an average experience in university teaching of 23.8 years (SD = 9.81). Before the questionnaire was administered, participants were informed about the purpose of this study, and they were informed of their right to withdraw from the study at any time and to be informed of its results. For more details on the sample, see Table 4.1.

Table 4.1. Description of the sample

	Mean	SD
Age	51.76	9.438
Experience (teaching)	23.79	9.811
Experience (using PPT)	14.31	4.517
	N	%
Area of knowledge		
Social sciences	42	39.6
Natural sciences	33	31.1
Medical sciences	31	29.2
Gender		
Men	57	53.8
Women	49	46.2

4.4.2. Design

This study used a structural equation model (SEM) approach to test and analyse a technology acceptance model (UTAUT2) in university lecturers, by administering a questionnaire adapted to the educational context. This questionnaire originally consists of several sections, two of which will be analysed in this particular paper. A first section of socio-labour data (career, age, gender, years of teaching experience, and years of experience using PowerPoint), and a section of measures designed to evaluate the different constructs of the model. The procedure for adapting the questionnaire used is detailed in the following section.

4.4.3. Measures and materials

A survey was designed to measure the seven constructs comprising the research model. Based on the original survey developed by Venkatesh, Thong and Xu (2012) for the UTAUT2, the survey contains 28 statements covering the seven constructs. However, since one of the original constructs was eliminated ("price value") and another was added (ATT), the final distribution varied slightly. In the case of IU, it became a direct measure, because the three items had a too similar wording, which simulated variance where the respondent probably could not differentiate one statement from another. Actual behaviour remained a direct self-reported measure. For the other constructs, their contents were adapted for the use of PowerPoint in the academy, and tested in a small sample of 10 university lecturers, to ensure that the writing of the items was coherent. The final questionnaire was composed of 20 items, distributed as follows: PE (3), EE (3), SI (2), FC (3), HM (3), HA (3), and ATT (3). Some examples of the items used are: "*PowerPoint is a useful tool for teaching my classes*" (PE), "*PowerPoint is easy to use*" (EE), "*Most of my colleagues use PowerPoint*" (SI), "*I enjoy using PowerPoint in my lectures*" (HM), "*I cannot conceive of teaching without using PowerPoint*" (HA). This instrument was tested using a confirmatory factor analysis (CFA), which is detailed in the Results section.

4.5.Results

4.5.1. Descriptive statistics

Before starting the analysis, the scales were tested to detect multicollinearity. None of the scales obtained values lower than .275 in a tolerance test, which suggests that there are no collinearity problems. Additionally, all scales show an acceptable level of normal distribution, with skewness <3.0 and kurtosis <10.0 (see Table 4.2), which are the maximum thresholds recommended by the current literature to perform a SEM (Kline, 2011).

Table 4.2. Normality of the model's constructs

Construct	Mean	SD	Skewness	Kurtosis
PE	4.42	1.24	-1.447	2.137
EE	5.37	0.61	-0.989	1.382
SI	4.37	1.25	-1.193	1.075
FC	5.63	0.53	-1.623	4.033
HM	3.51	1.24	-0.582	0.912
HA	2.86	1.76	-0.174	-1.126
ATT	2.90	1.26	-0.348	0.164
IU	3.53	1.79	-0.621	-0.512
AU	2.34	0.838	-1.011	0.034

Notes. PE = Performance expectancy; EE = Effort expectancy; SI = Social influence; FC = Facilitating conditions; HM = Hedonic motivation; HA = Habit; AT = Attitudes; IU = Intention to Use; AU = Actual Use.

4.5.2. Convergent validity

It is usually admitted that three criteria must be met in order to establish convergent validity (Teo, 2009): item reliability, convergent reliability of each construct using composite reliability (CR), and the average variance extracted (AVE). Three items were eliminated due to a low loading (> .50). The other items presented good standardized loading estimates, between .761 and .948, with the exception of one (.578), which still maintains a loading considered acceptable by many authors (Hair, Black, Babin, & Anderson, 2014). To consider a composite reliability as adequate, it is recommended that its values oscillate between .6 and .7 (Hair et al., 2014). In this study, the CRs had values between .68 and .92, far exceeding the recommended values. Finally, if the average variance extracted (AVE), proposed by Fornell and Larcker (1981) "*is less than .50, the variance due to measurement error is larger than the variance captured by the construct η, and the validity of the individual indicators (y_i), as well as the construct (η), is questionable*" (p. 46). As shown in Table 4.3, all values exceed the threshold of .50, thus implying that the convergent validity of the model constructs is adequate for subsequent analysis.

Table 4.3. Convergent validity of the measurement model

Constructs	# of items	Composite Reliability	Cronbach's alpha	AVE	Std loadings
PE	2	.826	.825	.704	PE1 (.820); PE2 (.858)
EE	3	.909	.905	.770	EE1 (.905); EE2 (.947); EE3 (.771)
SI	2	.801	.799	.670	SI1 (.761); SI2 (.872)
FC	2	.677	.652	.521	FC1 (.578); FC2 (.841)
HM	2	.781	.777	.641	HM1 (.836); HM3 (.763)
HA	3	.877	.879	.705	HA1 (.850); HA2 (.832); HA3 (.836)
AT	3	.919	.915	.792	AT1 (.943); AT2 (.928); AT3 (.791)

Notes. Fit indices: χ^2 = 165.200 (p < .001), df = 95; χ^2/df = 1.739, RMSEA = 0.084, CFI = .946, TLI = .922. PE = Performance expectancy; EE = Effort expectancy; SI = Social influence; FC = Facilitating conditions; HM = Hedonic motivation; HA = Habit; AT = Attitudes. All item loadings are significant at 0.01; the composite reliability score is calculated with the formula prescribed by Fornell and Larcker (1981).

4.5.3. Discriminant validity

The discriminant validity was evaluated following the criteria of Fornell and Larcker (1981), who suggest that the comparison between the square root of the AVE of a given construct must be greater than the correlation of that construct with any other construct of the model, so that the variance that explains its own measures is superior to the one it shares with other constructs (Hair et al., 2014). As can be seen in Table 4.4, all the square roots of the AVE were higher than the inter-factor correlations.

Table 4.4. Correlation of constructs and discriminant validity

		1	2	3	4	5	6	7
Performance Expectancy	1	**.839**						
Effort Expectancy	2	.014	**.878**					
Social Influence	3	.632**	.069	**.818**				
Facilitating Conditions	4	-.075	.483**	.049	**.722**			
Hedonic Motivation	5	.708**	.103	.541**	.174	**.800**		
Habit	6	.684**	.053	.524**	-.101	.577**	**.839**	
Attitudes	7	.711**	.082	.494**	.089	.742**	.680**	**.890**

Notes. Bolded diagonal elements are the square root of average variance extracted (AVE). These values should exceed inter-construct correlations (off-diagonal elements) for adequate discriminant validity.
**: Correlation is significant at the 0.01 level (two-tailed).

4.5.4. Model fit

The model was adjusted using the software AMOS v.24. Following the current recommendations, several goodness-of-fit indices have been used (see Teo, 2009). Hair and his colleagues (2014) suggest that using a combination of chi-square and its ratio with degrees of freedom, the Tucker-Lewis Index (TLI) or the Comparative Fit Index (CFI), and the Root Mean Square Error of Approximation (RMSEA), provides sufficient evidence of the fit of the model. In this study, all these indices were used, in addition to the traditional Goodness-of-Fit Index (GFI). To measure the fit of the model, two different models were evaluated, following the recommendations of Hair and colleagues (2014). The first model included all the paths proposed in the different hypotheses detailed in section 4.3 of this paper. The second model only included the paths with significant values. As shown in Table 4.5, the second model has a better fit than the full model, exceeding in all cases the recommended values, so this will be the model analysed in the following sections.

Table 4.5. Model fit indices

Model fit indices	Recommended value	Full Model	Final Model
Chi-squared (χ^2)	Non-significant	132.549, p<.001	37.791, p=.048
Degree of freedom (df)	-	50	25
Normed chi-squared (χ^2/df)	< 3	2.651	1.512
Goodness-of-Fit Index (GFI)	> .90	.939	.956
Tucker-Lewis Index (TLI)	> .90	.856	.968
Comparative Fit Index (CFI)	> .90	.983	.992
Root Mean Square Error of Approximation (RMSEA)	< .80	.125	.070

Notes. Recommended values based on Hair et al. (2014). The full model included all paths, final model included only significant paths.

4.5.5. Path analysis and hypothesis testing

The results show very different relationships to those proposed by the UTAUT2. First, EE ceases to be a significant antecedent, both of ATT and of IU. This may be because, in practice, PowerPoint is a widely known technology, which does not require significant efforts from its users. In fact, only FC ($\beta = .264$, $p <.01$) and ATT ($\beta = .209$, $p <.01$) predict IU, while the SI, PE, HA and HM variables do not have a significant effect on IU. On the other hand, PE ($\beta = .223$, $p <.01$) and HM ($\beta = .445$, $p <.001$) have a direct effect on ATT. It is interesting to note that HA has a direct effect on AU ($\beta = .305$, $p <.01$), but not on IU or ATT, as hypothesized before (H6A-C). Another path proposed in this study was the direct effect of SI on AU, which was significant ($\beta = .234$, $p <.01$). The result of each of the proposed hypotheses is detailed in Table 4.6.

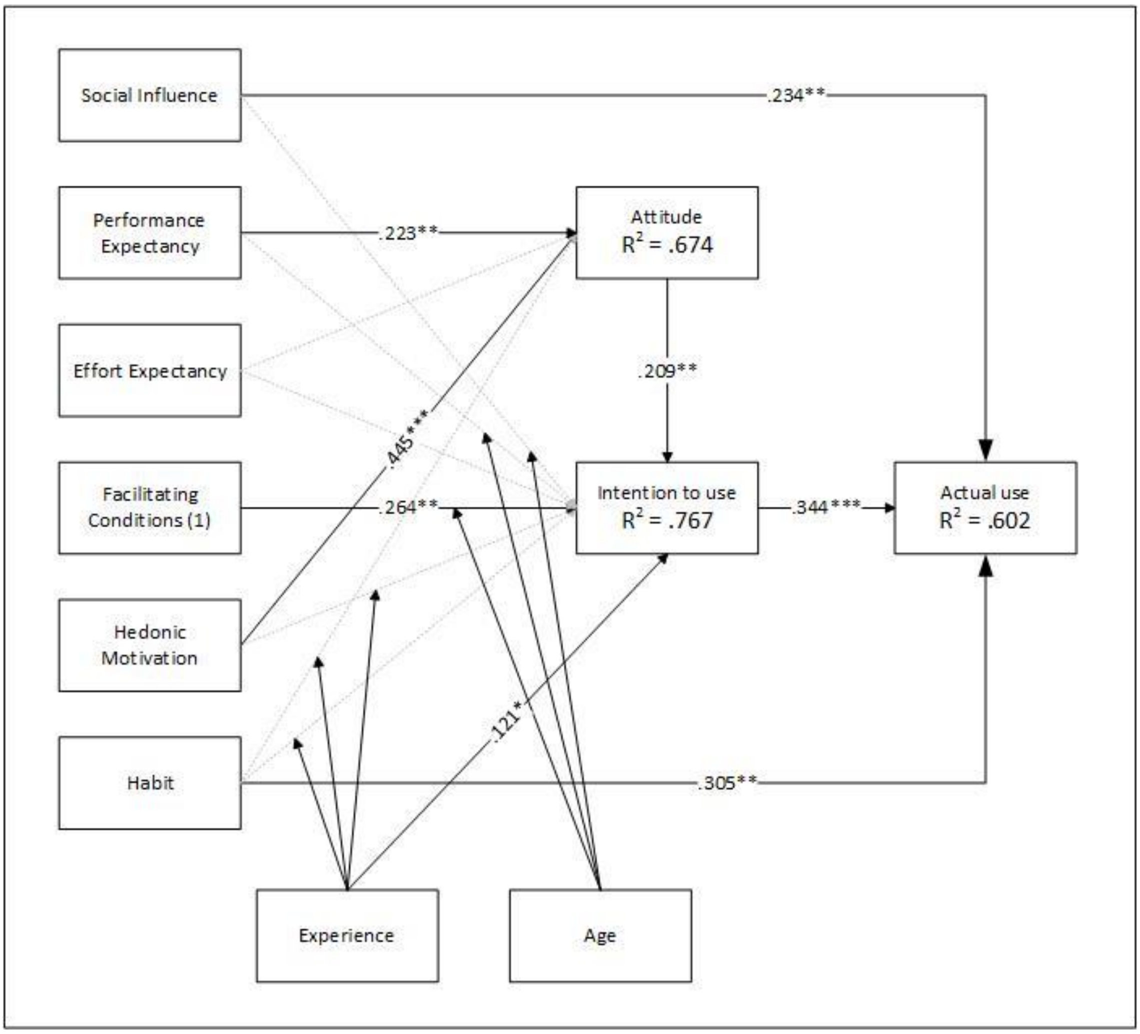
Table 4.6. Hypothesis testing results

Hypotheses	Path	Path coefficient	Result
H1A	SI → AU	.234**	Supported
H1B	SI → IU	n.s.	Not supported
H2A	PE → ATT	.223**	Supported
H2B	PE → IU	n.s.	Not supported
H3A	EE → ATT	n.s.	Not supported
H3B	EE → IU	n.s.	Not supported
H4	FC → IU	.264**	Supported
H5A	HM → ATT	.445***	Supported
H5B	HM → IU	n.s.	Not supported
H6A	HA → ATT	n.s.	Supported
H6B	HA → IU	n.s.	Supported
H6C	HA → AU	.305**	Supported
H7	ATT → IU	.209**	Supported
H8	IU → AU	.344***	Supported

**p < .01; ***p < .001; n.s. = non-significant.

In general, the model explains very well the variance of its three endogenous variables, especially in IU ($R^2 = .767$). PE and HM explain 67.4% of the variance of ATT, while UI, SI and HA explain 60.2% of the variance of AU. Regarding the moderating variables, no significant gender effects are found in the model, but the experience using PowerPoint does have a moderating effect on FC (β = -. 234, p <.05). Any other moderator effect found, referred to paths removed from the model (see Fig. 4.3). Additionally, the experience using PowerPoint also has a modest direct effect on UI (β = .121, p <.05).

Figure 4.3. Path analysis of the resulting model



Note. (1) Facilitating conditions is moderated by experience using PowerPoint (β=-.234, p<.05).
*p<.05; **p<.01; ***p<.001

4.6.Discussion

The results described above have four major implications. First, the results show that expectations regarding effort have no effect on the attitude toward this technology, or the intention to use it. A possible explanation for these results relates the possibility that the perception of effort fades over time (see Venkatesh et al., 2003), and that PowerPoint is a technology that is too widespread to generate an effort perception among its users - something that does not necessarily imply that they know how to use it (see Sharp et al., 2017).

Second, it emphasizes that social influence is no longer related to the intention to use PowerPoint, but directly to its use. This is very relevant. In effect, there is a clear contagion in the use of PowerPoint in the university. Many voices have criticized its use or even its pedagogical utility (Adams, 2006), but without success. The pressure perceived by the teachers themselves to continue using PowerPoint in their classes explains in part how, despite everything, no really strong movements against their use are observed. In fact, the teacher is usually between the pressure of his students, who demand a greater integration of technologies in the classroom (Ledbetter & Finn, 2018), and the perceived pressure of their own peers, who constantly use these technologies. Manning (2009) already showed the relevance of social norms in behaviour, either at the level of descriptive norms, in which the pressure comes from the behavioural observation of peers, or injuctives, in which the pressure is derived from the perception of peer expectations. That is to say, just seeing others use PowerPoint can be a sufficient source of social pressure to stimulate imitation behaviour. This study, unfortunately, did not consider evaluating both types of social influence separately.

Third, the attitude toward the use of PowerPoint seems to play a mediating role among some variables, specifically hedonic motivation and performance expectancy, and the intention to use PowerPoint. In their study, Šumak and Šorgo (2016) found that attitude mediated between PE and EE, and use. In this study, attitude was used as a mediator of intention to use, as originally proposed by the TAM (Davis, Bagozzi, &

Warshaw, 1989), and although EE is no longer significant, the attitude does again mediate the variable performance expectancy, which suggest that hedonic motivation corresponds here to the affective dimension of the attitude, whereas the performance expectancy represents its cognitive dimension.

Finally, the habit seems to play a relevant role in the use of PowerPoint. As expected, and because it is such a widespread technology, the use of PowerPoint seems to have become an automatic behaviour, which, in fact, explains the disappearance of effort expectancy in the model, and the relatively less central relevance of behavioural intention. Indeed, a repetitive and automatic behaviour hardly requires any mental effort for its enactment (Limayem, Hirt, & Cheung, 2007). How many times have we seen a teacher suspend a lecture because the projector did not work and he could not use his presentations? This behaviour, more common than might be expected, suggests that PowerPoint is no longer a didactic tool, but rather merges with the teaching practice itself.

4.6.1. Theoretical and practical relevance

This study has both practical and theoretical relevance. From a theoretical perspective, it presents a new model to analyse the use of technologies in educational contexts, especially in the case of tools of continuous use, such as PowerPoint. From a practical point of view, a parsimonious explanation about the maintenance of the use of PowerPoint in higher education is presented, highlighting the relevance of social influence and habit in a widespread pedagogical practice. This explanation requires more analysis and in more contexts, in order to prove its validity. However, it seems strong enough to suggest more studies in the future.

More importantly, this study is a wake-up call to the need for critical evaluation of the pedagogical practices that are implemented in classrooms. Technological tools such as PowerPoint can be of great help in certain cases, but it is necessary to first determine what the specific contribution of PowerPoint will be in the classroom. If it does not represent a clear contribution to student learning, its use should be dismissed as irrelevant. Habit and social pressure seem to be key elements in the use of PowerPoint, and teachers must become aware of it in order to really take advantage of PowerPoint's - or any other tool used in learning contexts for that matter - potential.

4.6.2. Limitations and future research

Limitations of this study relate to its moderate sample size (N=106) from two universities, which may affect its generalizability. However, a common rule of thumb is to have between 10 and 20 subjects per model parameter (Kline, 2011). In this study, with 106 participants for 9 parameters in the full model and 8 parameters in the final model, the parameter/participant ratio is roughly 1:12 for the full model and 1:13 for the final model. In terms of absolute sample size, Iacobucci (2010) stated that a sample size of 100 participants is usually sufficient in simple models. Second, the constructs were assessed using scales with few items, which affects the variability necessary to ensure that the model is valid. It would therefore be advisable to expand the questionnaires to include more items in each construct.

Future investigations with larger samples and an extended questionnaire could solve these problems. In addition, it would be interesting to deepen the concepts of habit and social influence, for example, to investigate which type of social influence has a stronger effect to predict the use of PowerPoint. Finally, this model could be used to evaluate other habitual pedagogical practices in university contexts.

4.7. Conclusion

PowerPoint seems to have slowly become a habit in university classrooms around the world. De Guineas and Markus (2009) remind us that every habit is a goal-directed behaviour. In this case, to communicate some information or knowledge with the student. But, in the process, there has not been a sufficiently extensive debate about the real opportunities that PowerPoint opens up - and the ones it does not. As other authors have pointed out, its linear language (Kinchin, Chadha, & Kokotailo, 2008) may not be ideal for all topics. Craig and Amernic (2006) exposed this problem with lucidity: "*as a community of educators and students, are we acquiescing to an unthinking acceptance of PowerPoint's imposition of a conduit metaphor to frame (educational) communication in a way in which 'language transfers thought to others' using words as a conduit?*" (p. 152).

Perhaps the rate of dissemination of PowerPoint in the academy was so vertiginous, that teachers simply got used to it before achieving any pedagogical reflection on its use. It is possible, as suggested by Adams (2006) in his compelling essay, that PowerPoint has changed the way teachers think about education, that the habit of using it, the automatism of its design, does not allow analysing the possibilities and advantages that offer other ways of teaching, either with or without PowerPoint. This study, indeed, does not seek to invalidate the use of PowerPoint in the university, but calls for a deep and constant deliberation on the pedagogical practices used in classrooms. As stated by Rose (2004), "*academics should be somewhat reflective about their use of tools, and thus not sound like Microsoft advertising executives*" (p. 797).

CAPITULO 5: CONCLUSIONES GENERALES

5.1.Introducción

Los estudios sobre los efectos de PowerPoint han crecido considerablemente en los últimos años (Baker et al., 2018), pero han centrado su atención en dos áreas prioritarias: efectividad y percepciones sobre su uso. Así, nos encontramos con numerosos estudios que indagan sobre características deseables en el diseño de diapositivas para que sean pedagógicamente efectivas (Bartsch & Cobern, 2003; Blokzijl & Andeweg, 2005; Cosgun Ögeyik, 2017; Grech, 2018; Pate & Posey, 2016), o sobre la disposición de copias impresas o digitales de las diapositivas y su efecto en el desempeño de los estudiantes (Kim, 2018; Worthington & Levasseur, 2015; Zdaniuk et al., 2017). Desde luego, estas son preguntas legítimas y necesarias, pero tienden a asumir una postura universalista de PowerPoint, de modo tal que no sólo resulta evidente que debe usarse, sino que el esfuerzo se centra en encontrar algunas normas generalizables para asegurar su máxima efectividad. En esta línea investigativa, se encuentran el CTML (Mayer, 2009, 2014) y IMTPC (Schnotz & Bannert, 2003), muy usados en los estudios actuales sobre PowerPoint.

En este trabajo, se han presentado los resultados de tres aproximaciones empíricas, con estudiantes (capítulo 2) y académicos (capítulos 3 y 4), respecto al uso de PowerPoint en educación superior. Aunque estos dos últimos capítulos correspondan en realidad a un solo gran estudio, se ha dividido en dos por la cantidad de información contenida en él, y los enfoques metodológicos diferentes usados con los datos obtenidos.

5.2.Conclusiones del trabajo de investigación

En primer lugar, los resultados sugieren que la postura universalista de PowerPoint antes descrita parece no ajustarse a la realidad. Desde luego que los avances propuestos por los modelos previos son valorables, sin embargo, los datos indican que PowerPoint tiene un componente fuertemente particularista y dependiente, no sólo del profesor, sino también del área del conocimiento al que pertenece. Por lo tanto, cuando Mayer (2009) destaca la importancia de presentaciones que combinen texto e imágenes para un aprendizaje efectivo de los estudiantes, esto no debe ser entendido como una 'regla de oro', sino como una recomendación a considerar cuando el caso lo amerite. Ciertamente, las imágenes pueden confundir a la audiencia (Bartsch & Cobern, 2003) tanto como un exceso de contenido textual. Es verdad que el diseño de las diapositivas es importante. Numerosas investigaciones lo demuestran (Grech, 2018), y no ha sido la intención del presente estudio desmontar este cuerpo teórico. Pero importan en un contexto epistemológico definido, no como leyes universales de aplicación general.

En el capítulo 2, por ejemplo, se ha detectado que, en algunos casos, la dualidad texto-imagen con la que se suele clasificar las diapositivas estáticas en este tipo de estudios podría no representar adecuadamente la realidad de algunas carreras. Lo que es más: la clasificación general de las carreras en ciencias duras (ciencias básicas y ciencias médicas) y ciencias blandas (ciencias sociales y humanidades) tampoco parece responder a todas las posibles alternativas epistemológicas. Específicamente, se observó que la carrera de Química no sólo tenía una cantidad inusitada de diapositivas textuales para una ciencia dura, sino que sistemáticamente se alejaba del perfil de ciencias duras, y parecía acercarse sutilmente a un perfil más asociado a ciencias blandas. Evidentemente, esto no quiere decir que las ciencias químicas sean un punto intermedio entre ciencias duras y blandas. Más bien parece indicar que existen otros perfiles, relacionados tanto con el contenido formal como con las claves comunicativas propias de cada disciplina. Así, la relevancia del lenguaje simbólico en la comunicación de las ciencias químicas podrían explicar la presencia de una alta proporción de diapositivas que podríamos llamar pseudo-textuales, dado que no se pueden clasificar como imágenes, pero su contenido, aunque textual en el sentido de componerse de números y letras, se corresponde en realidad con una categoría semiótica diferente al lenguaje común.

En los capítulos 3 y 4, debido al tamaño de la muestra, no se pudo realizar un análisis detallado por cada una de las carreras estudiadas. Sin embargo, de igual modo se pudo observar que las ciencias médicas no tienen el mismo patrón de uso que las ciencias naturales o que las ciencias sociales, lo que refuerza la noción de que la dualidad ciencias blandas-ciencias duras no es adecuada para evaluar el uso de PowerPoint en la educación superior.

En segundo lugar, nos encontramos con que las críticas a los modelos de tecnología educativa siguen aplicando fuertemente en el caso de PowerPoint. Los resultados del capítulo 4 sugieren que el uso mismo de PowerPoint se ha basado especialmente en un cierto desarrollo de automatismo por parte del cuerpo docente, no mediado por la reflexión crítica acerca de este uso. Pareciera que las presiones del entorno tienen una relevancia exacerbada cuando tratamos de entender por qué esta herramienta es tan usada. Mayoritariamente, los académicos usan PowerPoint por hábito y presión social, y no necesariamente porque piensen que es una herramienta útil para su desempeño profesional. De hecho, las expectativas profesionales de PowerPoint sólo tienen un efecto mediado por el desarrollo de actitudes positivas hacia su uso, mientras que tanto el hábito como la presión social tienen un efecto directo sobre el uso real de PowerPoint como herramienta pedagógica en las aulas de clases.

El modelo propuesto en el capítulo 4 proviene de una larga tradición en los estudios de gestión de los sistemas de información para indagar los mecanismos de adopción y uso de tecnologías en contextos empresariales. Precisamente, PowerPoint fue diseñado originalmente como un software de presentaciones ejecutivas, de modo que el modelo, con unas cuantas adaptaciones para el contexto educativo, funciona sin problemas. Lo sorprendente, es lo poco que se han transferido los hallazgos de una disciplina a otra. Bagozzi (2007) señala que los avances en psicología han sido lentos en integrarse al estudio de los sistemas de gestión de la información. Lo contrario puede decirse con tanto o más acierto. Mientras otras disciplinas parecen muy interesadas en saber por qué y cómo una tecnología se adopta, la psicología educacional no le ha prestado suficiente atención al tema, y no ha integrado con el suficiente rigor la experiencia y conocimientos provenientes de otras disciplinas. Ciertamente, se ha estudiado qué tecnologías educativas adoptan los estudiantes, cómo y por qué. Pero estudios con profesores, y especialmente académicos, son más bien escasos.

En tercer lugar, los resultados presentados en el capítulo 3 mostraron un relativamente alto uso de PowerPoint como insumo para que los estudiantes estudien para exámenes. Esta proporción es especialmente interesante por cuanto se asocia con un mayor automatismo y dependencia de PowerPoint. Zdaniuk, Gruman, y Cassidy (2017) encontraron que los estudiantes tienden a creer que acceder a PowerPoint es más útil que hablar con el profesor para aprender, y concluyen en su estudio que éstos sobreestiman el valor pedagógico de PowerPoint y subestiman el valor pedagógico de sus profesores. Nos parece que este hallazgo, abordado con bastante naturalidad por los autores, revela uno de los elementos más drásticos del (mal) uso de PowerPoint en educación superior: el rol protagónico de PowerPoint en el proceso de enseñanza, que está eclipsando el rol pedagógico del profesor. En efecto, ¿el problema radica en que los estudiantes perciben de forma errónea el valor pedagógico del profesor y de PowerPoint, como sugieren los autores? ¿O esa percepción se basa en el uso que efectivamente se le está dando a esta tecnología y, por tanto, al valor pedagógico que implícitamente se le atribuye, respectivamente, a profesor y a diapositivas? La pregunta es intrigante, pero ciertamente no ha sido abordada con suficiente entusiasmo en estudios anteriores.

5.3.Implicaciones del trabajo de investigación

Los resultados obtenidos en los capítulos 2, 3 y 4 del presente trabajo tienen una serie de implicaciones a nivel teórico, metodológico, y práctico.

A nivel teórico, quedan claras las falencias en estudios previos, que se basaban especialmente en dos dualidades para diseñar las investigaciones respecto al uso de PowerPoint en contextos educativos: la dualidad ciencias duras/ciencias blandas y formato visual/textual. A través de estas tres aproximaciones empíricas, parece claro que ninguna de ellas ha favorecido una comprensión clara del fenómeno de PowerPoint. Tal como se ha mencionado en la sección 5.2, el uso de estas categorías dicotómicas, si bien pueden facilitar el diseño de las investigaciones, parece reducir los resultados, y probablemente contribuyan a los resultados ambiguos que se han presentado en estudios previos. Especialmente, en el capítulo 2 se observó cómo carreras teóricamente afines del área de las ciencias duras, pueden presentar patrones muy diferentes en base a las formas comunicativas usadas en las diapositivas. También es de destacar que, incluso en las carreras con mayor proporción de imágenes, las diapositivas de tipo textual seguían siendo ampliamente usadas y, sin embargo, se apreció un efecto positivo en la atención y el aprendizaje percibidos de los estudiantes. El capítulo 3 abunda en estas diferencias, mostrando cómo, al agrupar las carreras en tres macrodisciplinas (ciencias sociales, médicas, y naturales), aparecen perfiles de uso diferenciados en cada una de ellas. Por lo tanto, se sugiere fuertemente incluir consideraciones teóricas respecto a las diferentes epistemologías disciplinarias al estudiar el uso de PowerPoint, no sólo en base al formato, sino en base a prácticas comunicativas específicas e inespecíficas, para detectar nuevas relaciones que puedan arrojar alguna luz sobre la efectividad de PowerPoint en contextos educacionales diversos.

A nivel metodológico, se mencionó una tercera dualidad: estudiante/profesor. Los estudios previos se han basado en gran medida en muestras estudiantiles para analizar la efectividad de PowerPoint, y especialmente, mediante medidas de satisfacción de los estudiantes. Sin embargo, existen diversos estudios que muestran que los estudiantes están sujetos a influencias externas a la hora de interpretar la efectividad de sus propios procesos de aprendizaje. Por ejemplo, las clases de un profesor carismático suelen ser mejor evaluadas que las clases de un profesor sin habilidades sociales, de forma independiente al contenido. Es perfectamente posible que PowerPoint produzca un efecto similar, de modo que contar sólo con muestras estudiantiles es insuficiente. En este trabajo, se ha mostrado cómo combinar muestras estudiantiles (capítulo 2) y de académicos (capítulos 3 y 4), para analizar conjuntamente el uso de PowerPoint. Aunque determinar la efectividad pedagógica de PowerPoint no fue un objetivo en este caso, es indudable que contar con perspectivas diversas enriquece tanto el análisis como las posibilidades interpretativas.

A nivel práctico, los resultados descritos en el capítulo 4 indican claramente que PowerPoint no está siendo aprovechado en todo su potencial. Los académicos lo usan principalmente por presión social y hábito, lo que indica un uso principalmente irreflexivo. No obstante, existe una tercera vía para predecir el uso de PowerPoint: la intención de usar, que se asocia con las actitudes hacia este uso y en la disponibilidad material para hacerlo. Esta es la vía “reflexiva”, en la que existe efectivamente una ponderación de beneficios. Esto es especialmente relevante por cuanto en el capítulo 3 se mostró que altos niveles de hábito usualmente se asociaban a una utilidad “no-crítica” (estudiar para exámenes o ejemplificar contenidos), mientras que bajos niveles de hábito se asociaban a una utilidad “crítica” (aprender conceptos claves o discutir contenidos relevantes). Aunque, desde luego, la utilidad no-crítica puede ser adecuada en determinados contextos, en ningún caso debiera ser una utilidad principal del uso de PowerPoint. Por lo tanto, las instituciones de educación superior debieran trabajar para facilitar la vía reflexiva del uso de PowerPoint, y poner limitaciones a la presión social por usarlo de forma irreflexiva, y hacer consciente que muchas veces, se trata de un hábito que puede reemplazarse por otras formas de entregar el material necesario.

5.4.Futuras líneas de investigación

Los resultados conjuntos obtenidos en los tres estudios presentados abren perspectivas interesantes para futuras investigaciones respecto al uso de PowerPoint en la educación superior.

Por una parte, queda en evidencia la necesidad de ampliar la base teórica que sustenta las investigaciones actuales, y pasar de una perspectiva universalista a una particularista. Por lo tanto, no se trata ya de investigar reglas universales para el correcto uso de PowerPoint, sino determinar reglas específicas para distintos contextos, tomando en consideración tanto las epistemologías propias de cada disciplina, como el objetivo pedagógico de las diapositivas. Como se observó en relación al estudio de Johnson y Christensen (2011), el simple cambio de diapositivas textuales a diapositivas visuales, sin considerar el contenido y el objetivo pedagógico, puede no tener sentido, incluso si son más llamativas para los estudiantes.

Del mismo modo, integrar perspectivas del área de la semiótica, que no sólo considere el aspecto estético de la diapositiva en términos de diseño, sino que tome en consideración el uso de otras formas de comunicación que no sean propiamente textuales o visuales, de modo que se pueda analizar cómo influyen diferentes tipos de comunicación en la efectividad de PowerPoint. El capítulo 2 ha dejado claro que esta influencia existe, y debe ser abordada en futuras investigaciones.

Una segunda línea de investigación se relaciona con profundizar en los hallazgos del capítulo 4, respecto al impacto del hábito y la presión social en el uso de PowerPoint. Aunque los resultados indican claramente esta asociación, no quedan claros los mecanismos mediante los cuales funcionan. ¿Qué tipo de presión social es la que activa el uso de PowerPoint, y por qué? ¿Qué factores contribuyen a la formación de un hábito en el uso de una tecnología educativa, y cómo influye en el valor pedagógico de PowerPoint?

Los resultados del capítulo 3 sugieren que el hábito se relaciona con un uso memorístico de PowerPoint, dirigido a convertir las diapositivas en material directo de estudio para los exámenes. Por otro lado, los académicos que reportan menores niveles de automatismo en su uso parecen decantarse por un uso que hemos denominado crítico de las diapositivas, por ejemplo, para estimular la reflexión crítica de los estudiantes. Sin embargo, como se ha puntualizado antes, esto no debe interpretarse en el sentido de una regla absoluta. En determinados casos, es probable que no puedan evitarse contenidos de tipo memorístico – por ejemplo, en relación a fechas o definiciones conceptuales formales. Futuras investigaciones deberían indagar en el impacto del hábito en el desarrollo de material de estudio con contenido memorístico. Por ejemplo, podríamos preguntarnos cómo afecta el nivel de hábito a la efectividad para presentar contenido de tipo memorístico. ¿Logran los académicos con altas puntuaciones en escalas de hábito enseñar contenido memorístico con la misma efectividad que académicos con bajas puntuaciones en estas escalas?

Finalmente, y considerando que la propuesta es pasar de una mirada universalista a una mirada particularista, la inclusión de perspectivas interculturales puede ser interesante de indagar. Los resultados de los estudios presentados sugieren que las categorías duales textual/visual y ciencias duras/ciencias blandas no se corresponden con la realidad, y además que factores como la presión social y la construcción de hábitos conductuales en los académicos afectan el uso de PowerPoint. Por lo tanto, no es imposible imaginar que contextos sociales más amplios también afecten el uso de PowerPoint, y sus efectos en los procesos de enseñanza-aprendizaje.

Referencias

Adams, C. (2006). PowerPoint, habits of mind, and classroom culture. *Journal of Curriculum Studies*, *38*(4), 389–411. https://doi.org/10.1080/00220270600579141

Aguaded, I. & Cabero, J. (2014). Avances y retos en la promoción de la innovación didáctica con las tecnologías emergentes e interactivas. *Educar, 50,* 67-83.

Ain, N., Kaur, K., & Waheed, M. (2016). The influence of learning value on learning management system use: An extension of UTAUT2. *Information Development, 32*(5), 1306–1321. https://doi.org/10.1177/0266666915597546

Amare, N. (2006). To slideware or not to slideware: Students' experiences with PowerPoint vs. lecture. *Journal of Technical Writing and Communication, 36*(3), 297-308. https://doi.org/10.2190/03gx-f1hw-vw5m-7dar

Apperson, J. M., Laws, E. L., & Scepansky, J. A. (2008). An assessment of student preferences for PowerPoint presentation structure in undergraduate courses. *Computers & Education, 50*(1), 148-153. https://doi.org/10.1016/j.compedu.2006.04.003

Area, M., Alonso, C., Correa, J. M., Moral, M. E., De-Pablos-Pons, J., Paredes, J., & Valverde, J. (2014). Las políticas educativas TIC en España después del Programa Escuela 2.0: las tendencias que emergen. *RELATEC: Revista Latinoamericana de Tecnología Educativa, 13*(2), 11–33.

Armour, C., Schneid, S. D., & Brandl, K. (2016). Writing on the board as students' preferred teaching modality in a physiology course. *Advances in Physiology Education, 40*(2), 229-233. https://doi.org/10.1152/advan.00130.2015

Ayres, P., & Sweller, J. (2014). The split-attention principle in multimedia learning. In R. Mayer (Ed.), *Cambridge handbook of multimedia learning* (pp. 135–146). New York: Cambridge University Press.

Bagozzi, R. (2007). The legacy of the technology acceptance model and a proposal for a paradigm shift. *Journal of the Association for Information Systems, 8*(4), 244-254.

Baker, J. P., Goodboy, A. K., Bowman, N. D., & Wright, A. A. (2018). Does teaching with PowerPoint increase students' learning? A meta-analysis. *Computers & Education*, *126*, 376–387. https://doi.org/10.1016/j.compedu.2018.08.003

Bartsch, R. A., & Cobern, K. M. (2003). Effectiveness of PowerPoint presentations in lectures. *Computers & Education*, *41*(1), 77–86. https://doi.org/10.1016/S0360-1315(03)00027-7

Benbasat, I., & Barki, H. (2007). Quo vadis, TAM? *Journal of the Association for Information Systems*, *8*(4), 211–218.

Biglan, A. (1973a). Relationships between subject matter characteristics and the structure and output of university departments. *Journal of Applied Psychology*, *57*, 204-213. https://doi.org/10.1037/h0034699

Biglan, A. (1973b). The characteristics of subject matter in different academic areas. *Journal of Applied Psychology*, *57*, 195-203. https://doi.org/10.1037/h0034701

Blokzijl, W., & Andeweg, B. (2005). The effects of text slide format and presentational quality on learning in college lectures. *Proceedings of the International Professional Communication Conference 2005*, 288–299. https://doi.org/10.1109/IPCC.2005.1494188

Bohay, M., Blakely, D. P., Tamplin, A. K., & Radvansky, G. A. (2011). Note taking, review, memory, and comprehension. *The American Journal of Psychology, 124*(1), 63-73. https://doi.org/10.5406/amerjpsyc.124.1.0063

Brännback, M., Nikou, S., & Bouwman, H. (2017). Value systems and intentions to interact in social media: The digital natives. *Telematics and Informatics*, *34*(4), 365–381. https://doi.org/10.1016/j.tele.2016.08.018

Braxton, J. M. (1995). Disciplines with and affinity for the improvement of undergraduate education. *New Directions for Teaching and Learning, 64*, 59-64. https://doi.org/10.1002/tl.37219956409

Burke, L. A., James K., & Ahmadi, M. (2009). Effectiveness of PowerPoint-based lectures across different business disciplines: An investigation and implications. *Journal of Education for Business, 83*, 246-251. https://doi.org/10.3200/joeb.84.4.246-251

Cabero, J. (2003). Replanteando la tecnología educativa. *Comunicar, 21*, 23-30.

Cabero, J. (2016). ¿Qué debemos aprender de las pasadas investigaciones en tecnología educativa? *Revista Interuniversitaria de Investigación en Tecnología Educativa (RiiTE), 0*, 23-33.

Cashin, W. E., & Downey, R. G. (1995). Disciplinary differences in what is taught and in students' perceptions of what they learn and of how they are taught. *New Directions for Teaching and Learning, 64*, 81-92. https://doi.org/10.1002/tl.37219956412

Castelló, A., & Cladellas, R. (2013). La evaluación de la comprensión en el aprendizaje: El empleo de las TIC en el análisis de estructuras de conocimiento. *Estudios* *pedagógicos, 39*(ESPECIAL), 41-57. https://doi.org/10.4067/s0718-07052013000300004

Chávez, D., Cladellas, R., & Castelló, T. (en prensa). Patterns of PowerPoint Use in Higher Education: A Comparison between Natural, Medical, and Social Sciences. *Innovative Higher Education, 45*(1).

Cladellas, R., Castelló, A., Badia, M., & Cirera, M. C. (2013). Effects of the PowerPoint methodology on content learning. *Intangible Capital, 9*(1), 184-198.

Cladellas, R., & Castelló, A. (2017). Percepción del aprendizaje, procedimientos de evaluación y uso de la tecnología PowerPoint en la formación universitaria de Medicina. *Intangible Capital, 13*(2), 302-318. https://doi.org/10.3926/ic.814

Cosgun Ögeyik, M. (2017). The effectiveness of PowerPoint presentation and conventional lecture on pedagogical content knowledge attainment. *Innovations in Education and Teaching International*, *54*, 503–510. https://doi.org/10.1080/14703297.2016.1250663

Costa, M. L., Van Rensburg, L., & Rushton, N. (2007). Does teaching style matter? A randomised trial of group discussion versus lectures in orthopaedic undergraduate teaching. *Medical Education, 41*(2), 214-217. https://doi.org/10.1111/j.1365-2929.2006.02677.x

Craig, R. J., & Amernic, J. H. (2006). PowerPoint presentation technology and the dynamics of teaching. *Innovative Higher Education*, *31*(3), 147–160. https://doi.org/10.1007/s10755-006-9017-5

Cullen, A. E., Williams, J. L., & McCarley, N. G. (2018). Conscientiousness and learning via feedback to identify relevant information on PowerPoint slides. *North American Journal of Psychology*, *20*, 425–444.

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, *13*(3), 319–340. https://doi.org/10.2307/249008

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. *Management Science*, *35*(8), 982–1003. https://doi.org/10.1287/mnsc.35.8.982

de Guinea, & Markus. (2009). Why Break the Habit of a Lifetime? Rethinking the Roles of Intention, Habit, and Emotion in Continuing Information Technology Use. *MIS Quarterly*, *33*(3), 433. https://doi.org/10.2307/20650303

Deslauriers, L., McCarty, L. S., Miller, K., Callaghan, K., & Kestin, G. (2019). Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom. *Proceedings of the National Academy of Sciences*, 201821936.

Entwistle, N., & Tait, H. (1995). Approaches to studying and perceptions of the learning environment across disciplines. *New Directions for Teaching and Learning, 64*, 93-103. https://doi.org/10.1002/tl.37219956413

Erwin, T. D., & Rieppi, R. (1999). Comparing multimedia and traditional approaches in undergraduate psychology classes. *Teaching of Psychology, 26*(1), 58-61. https://doi.org/10.1207/s15328023top2601_18

Fornell, C., & Larcker, D. F. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research*, *18*(1), 39–50. https://doi.org/10.2307/3151312

Frank, J., L. Shaw, & E. Wilson. (2008). The Impact of Providing Web-Based PowerPoint Slides as Study Guides in Undergraduate Business Classes. *Journal of Educational Technology Systems, 37*(2), 217–229.

Franklin, J., & Theall, M. (1995). The relationship of disciplinary differences and the value of class preparation time to student ratings of teaching. *New Directions for Teaching and Learning*, *64*, 41-48. https://doi.org/10.1002/tl.37219956407

Garrett, N. (2015). PowerPoint outside class: The impact of slide design on student use. *Journal of Educational Technology Systems*, *44*(1), 69-85. https://doi.org/10.1177/0047239515598521

Garrett, N. (2016). How do academic disciplines use PowerPoint? *Innovative Higher Education*, *41*(5), 365-380. https://doi.org/10.1007/s10755-016-9381-8

Gellerstedt, M., Babaheidari, S. M., & Svensson, L. (2018). A first step towards a model for teachers' adoption of ICT pedagogy in schools. *Heliyon*, *4*(9), e00786. https://doi.org/10.1016/j.heliyon.2018.e00786

Ginns, P. (2005). Meta-analysis of the modality effect. *Learning and Instruction*, *15*, 313-331. https://doi.org/10.1016/j.learninstruc.2005.07.001

Gladic-Miralles, J., & Cautín-Epifani, V. (2018). Niveles de comprensión y su relación con la predominancia de sistemas semióticos: una aproximación a la comprensión multimodal desde el discurso académico. *Estudios pedagógicos (Valdivia)*, *44*(1), 293-313. https://doi.org/10.4067/s0718-07052018000100293

Grech, V. (2018). The application of the Mayer multimedia learning theory to medical PowerPoint slide show presentations. *Journal of Visual Communication in Medicine*, *41*, 36–41. https://doi.org/10.1080/17453054.2017.1408400

Gros, B. (2016). Retos y tendencias sobre el futuro de la investigación acerca del aprendizaje con tecnologías digitales. *RED. Revista de Educación a Distancia, 50*, 1-13.

Hair, J. F., Black, W., Babin, B., & Anderson, R. (2014). *Multivariate data analysis* (7. ed.). Harlow: Pearson.

Hallewell, M. J., & Lackovic, N. (2017). Do pictures "tell" a thousand words in lectures? How lecturers vocalise photographs in their presentations. *Higher Education Research & Development*, *36*, 1166–1180. https://doi.org/10.1080/07294360.2017.1303454

Hartnett, N., Römcke, J., & Yap, C. (2003). Recognizing the importance of instruction style to students' performance: some observations from laboratory research–a research note. *Accounting Education, 12*(3), 313-331. https://doi.org/10.1080/0963928032000095446

Hertz, B., van Woerkum, C., & Kerkhof, P. (2015). Why do scholars use PowerPoint the way they do? *Business and Professional Communication Quarterly*, *78*, 273–291. https://doi.org/10.1177/2329490615589171

Hill, A., Arford, T., Lubitow, A., & Smollin, L. M. (2012). "I'm ambivalent about it" The dilemmas of PowerPoint. *Teaching Sociology*, *40*(3), 242-256. https://doi.org/10.1177/0092055x12444071

Hughes, I. E. (2003). Changes in use of technological methods of teaching and learning in undergraduate pharmacology in UK higher education. *Bioscience Education, 1*(1), 1-7. https://doi.org/10.3108/beej.2003.01010001

Huxham, M. (2010). The medium makes the message: Effects of cues on students' lecture notes. *Active Learning in Higher Education*, *11*, 179–188. https://doi.org/10.1177/1469787410379681

Iacobucci, D. (2010). Structural equations modeling: Fit Indices, sample size, and advanced topics. *Journal of Consumer Psychology*, *20*(1), 90–98. https://doi.org/10.1016/j.jcps.2009.09.003

James, K. E., Burke, L. A., & Hutchins, H. M. (2006). Powerful or pointless? Faculty versus student perceptions of PowerPoint use in business education. *Business Communication Quarterly*, *69*, 374–396. http://doi.org/10.1177/1080569906294634

Johnson, D. A., & Christensen, J. (2011). A comparison of simplified-visually rich and traditional presentation styles. *Teaching of Psychology*, *38*(4), 293–297. https://doi.org/10.1177/0098628311421333

Kahraman, S., Çevik, C.,& Kodan, H. (2011). Investigation of university students' attitude toward the use of PowerPoint according to some variables. *Procedia Computer Science*, *3*, 1341–1347. http://doi.org/10.1016/j.procs.2011.01.013

Kim, H. (2018). Impact of slide-based lectures on undergraduate students' learning: Mixed effects of accessibility to slides, differences in note-taking, and memory term. *Computers & Education*, *123*, 13–25. https://doi.org/10.1016/j.compedu.2018.04.004

Kinchin, I. M., Chadha, D., & Kokotailo, P. (2008). Using PowerPoint as a lens to focus on linearity in teaching. *Journal of Further and Higher Education*, *32*(4), 333–346. https://doi.org/10.1080/03098770802392923

King, W. R., & He, J. (2006). A meta-analysis of the technology acceptance model. *Information & Management*, *43*(6), 740–755. https://doi.org/10.1016/j.im.2006.05.003

Klemenčič M., Chirikov I. (2015) How do we know how students experience higher education? On the use of student surveys. In A. Curaj, L. Matei, R. Pricopie, J. Salmi, & P. Scott. (Eds.), *The European higher education area: Between critical reflections and future policies* (pp. 367-386). Dordrecht: Springer.

Kline, R. B. (2011). *Principles and practice of structural equation modeling* (3rd ed.). New York: Guilford Press.

Koles, P. G., Stolfi, A., Borges, N. J., Nelson, S., & Parmelee, D. X. (2010). The impact of team-based learning on medical students' academic performance. *Academic Medicine, 85*(11), 1739-1745. https://doi.org/10.1097/acm.0b013e3181f52bed

Lawless, K. A. (2016). Educational technology: False profit or sacrificial lamb? A review of policy, research, and practice. *Policy Insights from the Behavioral and Brain Sciences*, *3*(2), 169–176.

Ledbetter, A. M., & Finn, A. N. (2018). Perceived teacher credibility and students' affect as a function of instructors' use of PowerPoint and email. *Communication Education*, *67*(1), 31–51. https://doi.org/10.1080/03634523.2017.1385821

Levasseur, D. G., & Sawyer, K. (2006). Pedagogy meets PowerPoint: A research review of the effects of computer-generated slides in the classroom. *Review of Communication*, *6*(1–2), 101–123. https://doi.org/10.1080/15358590600763383

Limayem, Hirt, & Cheung. (2007). How Habit Limits the Predictive Power of Intention: The Case of Information Systems Continuance. *MIS Quarterly*, *31*(4), 705. https://doi.org/10.2307/25148817

Lin, L. J., & Atkinson, R. K. (2011). Using animations and visual cueing to support learning of scientific concept and processes. *Computers & Education, 56*, 650–658. https://doi.org/10.1016/j.compedu.2010.10.007

López, M. (2009). Reflexiones acerca de las tecnologías de la información y la comunicación. *Tekhné*, *6*, 26-31.

Low, R., & Sweller, J. (2005). The modality principle in multimedia learning. In R. Mayer (Ed.), *Cambridge handbook of multimedia learning* (pp. 147–158). New York: Cambridge University Press.

MacKiewicz, J. (2008). Comparing Powerpoint experts' and university students' opinions about PowerPoint presentations. *Journal of Technical Writing and Communication*, *38*, 149–165. https://doi.org/10.2190/TW.38.2.d

Manning, M. (2009). The effects of subjective norms on behaviour in the theory of planned behaviour: A meta-analysis. *British Journal of Social Psychology*, *48*(4), 649–705. https://doi.org/10.1348/014466608X393136

Marsh, E. J., & Sink, H. E. (2010). Access to handouts of presentation slides during lecture: Consequences for learning. *Applied Cognitive Psychology, 24*(5), 691-706.

Mason, L., Tornatora, M. C., & Pluchino, P. (2013). Do fourth graders integrate text and picture in processing and learning from an illustrated science text? Evidence from eye-movement patterns. *Computers & Education, 60*(1), 95-109. https://doi.org/10.1016/j.compedu.2012.07.011

Mayer, R. E. (1999). Multimedia aids to problem-solving transfer. *International Journal of Educational Research, 31*, 611-623. https://doi.org/10.1016/s0883-0355(99)00027-0

Mayer, R. E. (2009). *Multimedia learning*. Cambridge: Cambridge University Press.

Mayer, R. E. (2014). Cognitive theory of multimedia learning. In R.E. Mayer (Ed.), *The Cambridge Handbook of Multimedia Learning* (pp. 43-71). Cambridge: Cambridge University Press. https://doi.org/10.1017/cbo9781139547369.005

Mayer, R. E., & Johnson, C. I. (2008). Revising the redundancy principle in multimedia learning. *Journal of Educational Psychology, 100*(2), 380-386. https://doi.org/10.1037/0022-0663.100.2.380

Mayer, R. E., & Moreno, R. (2002). Animation as an aid to multimedia learning. *Educational Psychology Review, 14*(1), 87-99.

Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist, 38*, 43–52. https://doi.org/10.1207/S15326985EP3801_6

Moreno, R., & Mayer, R. E. (1999). Cognitive principles of multimedia learning: The role of modality and contiguity. *Journal of Educational Psychology, 91*(2), 358-368. https://doi.org/10.1037//0022-0663.91.2.358

Moulton, S. T., Türkay, S., & Kosslyn, S. M. (2017). Does a presentation’s medium affect its message? PowerPoint, Prezi, and oral presentations. *PLOS ONE, 12*(7), e0178774. https://doi.org/10.1371/journal.pone.0178774

Naftulin, D. H.,Ware, J. E., & Donnelly, F. A. (1973). The Doctor Fox lecture: A paradigm of educational seduction. *Journal of Medical Education, 48*, 630-635.

Paas, F., & Sweller, J. (2014). Implications of cognitive load theory for multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 27-42). Cambridge: Cambridge University Press. https://doi.org/10.1017/cbo9781139547369.004

Paas, F., Renkl, A., & Sweller, J. (2003). Cognitive load theory and instructional design: Recent developments. *Educational Psychologist, 38*(1), 1-4. https://doi.org/10.1207/s15326985ep3801_1

Paivio, A. (1986). *Mental representation: A dual coding approach*. New York. Oxford University Press.

Parodi, G. (2010). Multisemiosis y lingüística de corpus: Artefactos (multi) semióticos en los textos de seis disciplines en el corpus PUV-2010. *Revista de Lingüística Teórica y Aplicada (RLA), 48*(2), 33-70. https://doi.org/10.4067/s0718-48832010000200003

Pate, A., & Posey, S. (2016). Effects of applying multimedia design principles in PowerPoint lecture redesign. *Currents in Pharmacy Teaching and Learning*, *8*, 235–239. https://doi.org/10.1016/j.cptl.2015.12.014

Piolat, A., Olive, T., & Kellogg, R. T. (2005). Cognitive effort during note taking. *Applied Cognitive Psychology, 19*(3), 291-312. https://doi.org/10.1002/acp.1086

Plass, J. L., Moreno, R., & Brünken, R. (2010). *Cognitive load theory*. New York, NY: Cambridge University Press. https://doi.org/10.1017/cbo9780511844744.001

Richardson, D. (2008). Don't dump the didactic lecture; fix it. *Advances in Physiology Education, 32*(1), 23-24. https://doi.org/10.1152/advan.00048.2007

Rickman, J., & Grudzinski, M. (2000). Student expectations of information technology use in the classroom. *Educause Quarterly*, *23*(1), 24-30.

Roberts, D. (2018a). The engagement agenda, multimedia learning and the use of images in higher education lecturing: Or, how to end death by PowerPoint. *Journal of Further and Higher Education*, *42*, 969–985. https://doi.org/10.1080/0309877X.2017.1332356

Roberts, D. (2018b). “The message is the medium”: Evaluating the use of visual images to provoke engagement and active learning in politics and international relations lectures. *Politics*, *38*, 232–249. https://doi.org/10.1177/0263395717717229

Roehling, P. V., & Trent-Brown, S. (2011). Differential use and benefits of PowerPoint in upper level versus lower level courses. *Technology, Pedagogy and Education, 20*(1), 113-124. https://doi.org/10.1080/1475939x.2011.554018

Rose, G. (2004). On the Importance of Asking the Right Questions, or What is the Power of PowerPoint, Exactly? *Antipode*, *36*(5), 795–797. https://doi.org/10.1111/j.1467-8330.2004.00453.x

Schüler, A., Arndt, J., & Scheiter, K. (2015). Processing multimedia material: Does integration of text and pictures result in a single or two interconnected mental representations? *Learning and Instruction*, *35*, 62–72. https://doi.org/10.1016/j.learninstruc.2014.09.005

Schnotz, W. (2005). An integrated model of text and picture comprehension. In R. Mayer (Ed.), *The Cambridge Handbook of Multimedia Learning* (pp.49-69). New York: CUP. https://doi.org/10.1017/cbo9780511816819.005

Schnotz, W., & Bannert, M. (2003). Construction and interference in learning from multiple representations. *Learning and Instruction*, *13*, 141-156. https://doi.org/10.1016/s0959-4752(02)00017-8

Schraw, G. (2001). Promoting General Metacognitive Awareness. In H. Hartman (Ed.), *Metacognition in Learning and Instruction* (pp. 3-16). Dordrecht: Kluwer Academic Publisher.

Schweppe, J., & Rummer, R. (2016). Integrating written text and graphics as a desirable difficulty in long-term multimedia learning. *Computers in Human Behavior, 60*, 131-137. https://doi.org/10.1016/j.chb.2016.02.035

Seth, V., Upadhyaya, P., Ahmad, M., & Moghe, V. (2010). PowerPoint or chalk and talk: Perceptions of medical students versus dental students in a medical college in India. *Advances in Medical Education and Practice*, *1*, 11. https://doi.org/10.2147/amep.s12154

Sharp, J. G., Hemmings, B., Kay, R., Murphy, B., & Elliott, S. (2017). Academic boredom among students in higher education: A mixed-methods exploration of characteristics, contributors and consequences. *Journal of Further and Higher Education*, *41*(5), 657–677. https://doi.org/10.1080/0309877X.2016.1159292

Shigli, K., Agrawal, N., Nair, C., Sajjan, S., Kakodkar, P., & Hebbal, M. (2016). Use of PowerPoint presentation as a teaching tool for undergraduate students in the subject of gerodontology. *The Journal of Indian Prosthodontic Society*, *16*, 187–192. https://doi.org/10.4103/0972-4052.167940

Smart, J. C., & Elton, C. F. (1975). Goal orientations of academic departments: A test of Biglan's model. *Journal of Applied Psychology*, *60*(5), 580-588. https://doi.org/10.1037//0021-9010.60.5.580

Smart, J. C., & Elton, C. F. (1982). Validation of the Biglan model. *Research in Higher Education, 17*(3), 213-229. https://doi.org/10.1007/bf00976699

Smith, S.D., & Caruso, J.B. (2010). *The ECAR study of undergraduate students and information technology, 2010* [Research study]. Retrieved from Educause website: https://library.educause.edu/-/media/files/library/2010/10/ers1006w-pdf.pdf

Smith-Peavler, E., Gardner, G., & Otter, R. (2019). PowerPoint use in the undergraduate biology classroom: Perceptions and impacts on student learning. *Journal of College Science Teaching*, *48*(3), 74–83. https://doi.org/10.2505/4/jcst19_048_03_74

Šumak, B., & Šorgo, A. (2016). The acceptance and use of interactive whiteboards among teachers: Differences in UTAUT determinants between pre- and post-adopters. *Computers in Human Behavior*, *64*, 602–620. https://doi.org/10.1016/j.chb.2016.07.037

Sweller, J. (1994). Cognitive load theory learning difficulty and instructional design. *Learning and Instruction, 4*, 295-312. https://doi.org/10.1016/0959-4752(94)90003-5

Sweller, J. (1999). *Instructional design in technical areas*. Camberwell, Australia: ACER.

Sweller, J., Ayres, P., & Kalyuga, S. (2011). The redundancy effect. In J. M. Spector & S. P. Lajoie (Eds.), *Cognitive load theory* (pp. 141–154). New York, NY: Springer.

Sweller, J., Van Merrienboer, J. J., & Paas, F. G. (1998). Cognitive architecture and instructional design. *Educational Psychology Review*, *10*(3), 251-296.

Teo, T. (2009). Modelling technology acceptance in education: A study of pre-service teachers. *Computers & Education*, *52*(2), 302–312. https://doi.org/10.1016/j.compedu.2008.08.006

Van der Meij, J., & de Jong, T. (2006). Supporting students' learning with multiple representations in a dynamic simulation-based learning environment. *Learning and Instruction*, *16*(3), 199-212. https://doi.org/10.1016/j.learninstruc.2006.03.007

Van Merriënboer, J. J. G. (1997). *Training complex cognitive skills*. Englewood Cliffs, NJ: Educational Technology Publications.

Venkatesh, Morris, Davis, & Davis. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly*, *27*(3), 425. https://doi.org/10.2307/30036540

Venkatesh, V., Thong, J. Y. L., & Xu, X. (2012). Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology. *MIS Quarterly*, *36*(1), 157–178.

Webber, K. L. (2011). The use of learner-centered assessment in us colleges and universities. *Research in Higher Education*, *53*, 201-228. https://doi.org/10.1007/s11162-011-9245-0

Williams, J. L., McCarley, N. G., Sharpe, J. L., & Johnson, C. E. (2017). The ability to discern relevant from irrelevant information on PowerPoint slides: A key ingredient to the efficacy of performance feedback. *North American Journal of Psychology*, *19*, 219–236.

Wisniewski, C. S. (2018). Development and impact of a simplified approach to didactic PowerPoint presentations performed in a drug information course. *Currents in*

Pharmacy Teaching and Learning, *10*, 291–297. https://doi.org/10.1016/j.cptl.2017.11.004

Worthington, D. L., & Levasseur, D. G. (2015). To provide or not to provide course PowerPoint slides? The impact of instructor-provided slides upon student attendance and performance. *Computers & Education*, *85*, 14–22. https://doi.org/10.1016/j.compedu.2015.02.002

Yilmazel-Sahin, Y. (2009). A comparison of graduate and undergraduate teacher education students' perceptions of their instructors' use of Microsoft PowerPoint. *Technology, Pedagogy and Education*, *18*, 361–380. https://doi.org/10.1080/14759390903335866

Zdaniuk, A., Gruman, J. A., & Cassidy, S. A. (2017). PowerPoint slide provision and student performance: the moderating roles of self-efficacy and gender. *Journal of Further and Higher Education*, *43*, 467-481. https://doi.org/10.1080/0309877X.2017.1367369