UNIVERSITY COMPLUTENSE OF MADRID
Faculty of Education
Department of Didactics and School Organization

UNIVERSIDAD
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TOWARDS AN INTEGRATED INSTRUCTIONAL MODEL FOR THE DESIGN OF COMMON LEARNING RESOURCES IN ENGINEERING EDUCATION FOR ACADEMIA AND INDUSTRY

HACIA UN MODELO INSTRUCCIONAL INTEGRADO PARA EL DISEÑO DE RECURSOS DE APRENDIZAJE COMUNES EN LA EDUCACIÓN EN INGENIERÍA PARA LA ACADEMIA Y LA INDUSTRIA

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy in Education

Under the direction of Dr. Carmen Alba Pastor
Rémy Crepon

rcrepon@ucm.es

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FACULTAD DE EDUCACIÓN

Departamento de Didáctica y Organización Escolar

TESIS DOCTORAL

Towards an integrated instructional model for the design of common learning resources in engineering education for academia and industry

Hacia un modelo instruccional integrado para el diseño de recursos de aprendizaje comunes en la educación en ingeniería para la academia y la industria

MEMORIA PARA OPTAR AL GRADO DE DOCTOR

PRESENTADA POR

Rémy Crepon

Directora

Carmen Alba Pastor

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PREVIOUS PUBLICATIONS

Part of the work has been previously published and presented at the following conferences:

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Crepon, R. (2013). Common Learning Resources for Academia & Industry, *Proceedings of the SEFI2013 Conference*, SEFI, Leuven, Belgium, source: www.sefi.be, author: R.Crepon.

Crepon, R. (2014a). Description of an e-Learning Tutorial in Geostatistics Delivered at one University and at one Company. *Proceedings of the SEFI2014 Conference*, SEFI, Birmingham, UK, source: www.sefi.be, author: R.Crepon.

Crepon, R. (2014b). Application of Design Research Methodology to a Context-Sensitive Study in Engineering Education. *Proceedings of the FIE2014 Conference*, IEEE, Madrid, Spain, source: http://ieeexplore.ieee.org/, ISSN :0190-5848, DOI: 10.1109/FIE.2014.7044254, p. 1631-1634.

Crepon, R. (2015a). Using Common Learning Resources in Academia and Industry: From Practice to Theory. *Proceedings of the SEFI2015 Conference*, SEFI, Orléans, France, source: www.sefi.be, author: R.Crepon.

Crepon, R. (2015b). Closing the University-Business Gap: Model of Blended Learning for the Collaborative Design of Learning Resources. *Proceedings of the REES2015 Conference*, Dublin, Ireland.

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LIST OF ABBREVIATIONS

English

B: Business
BL: Blended Learning
BSc: Bachelor of Science
CBT: Computer Based Training
DBR: Design Based Research
EE: Engineering Education
E&T: Education and Technology
FWBL: Facilitated Working Based Learning
HEI: Higher Education Institutions
HR: Human Resources
ICT: Information and Communications Technology
ID: Instructional Design
IP: Intellectual Property
LMS: Learning Management System
LO: Learning Object
LR: Learning Resource
MSc: Master of Science
OER: Open Educational Resource
R&D: Research & Development
U: University
UBC: University-Business Collaboration
WBL: Work Based Learning

Español

AFE: Análisis Factorial Exploratorio
CTIM: Ciencia, Tecnología, Ingeniería y Matemáticas
CUE: Colaboración Universidad-Empresa
DME: Diseño de Materiales Educativos
EAO: Enseñanza Asistida por Ordenador
IBD: Investigación Basada en el Diseño
I+D: Investigación y Desarrollo
IES: Instituciones de Educación Superior
TIC: Tecnologías de Información y Comunicaciones

RESUMEN

1. MARCO TEÓRICO

En las sociedades del conocimiento se considera que la Colaboración entre Universidad y Empresa (CUE) en ingeniería y diseño es una de las principales contribuciones a la educación y titulaciones de calidad y a la generación de innovación y crecimiento económico.

1.1. Educación en ingeniería

En la *Encyclopaedia Britannica* (2016), la "ingeniería" se define como "la aplicación de la ciencia para convertir de forma óptima los recursos de la naturaleza a los propósitos de la humanidad". En una economía global e impulsada por el conocimiento se considera que la transformación del conocimiento en productos, procesos y servicios es crítica para la competitividad, el crecimiento a largo plazo de la productividad y la generación de riqueza (Duderstadt, 2010).

Al final de la década de los sesenta surgieron en Europa nuevos tipos de instituciones de educación profesional universitaria y superior, que orientaban sus planes de estudios a profesiones que satisficieran las necesidades de la industria local (Christensen & Newberry, 2015; Collis & Strijker, 2004; Jonassen, 1999). El análisis de los tres componentes del triángulo didáctico, es decir, el profesor, el aprendiz y el contenido, permite hacer una comparación de las prácticas de las Instituciones de Educación Superior (IES) y de las empresas. Primero, los estudiantes y los empleados tienen tendencias o modelos diferentes para aprender, según su experiencia. Mientras que los aprendices maduros se motivan solos y saben cómo aprenden, el conocimiento previo podría hacer más difícil que se aprendan cosas nuevas (Knowles, Holton, & Swanson, 2012). Para ambas poblaciones la enseñanza debe suponer un desafío intelectual suficiente como para motivarles (Heywood, 2005; Mayer, 2009) y el aprendizaje en situaciones reales parece ayudar a que se produzca aprendizaje (Aubrun & Colin, 2015; Heywood, 2005; Knowles et al., 2012). Respecto a la enseñanza y a los recursos educativos empleados por las IES, la práctica depende del tipo de contexto en que se introduzca en la universidad. En el modelo liberal los profesores tienen toda la responsabilidad, mientras que en el modelo de investigación se considera que la enseñanza tiene un valor relativamente bajo; y en un modelo de servicio el equipo docente desarrolla, mantiene y cultiva relaciones profesionales (Alpay & Verschoor, 2014; Brémaud & Boisclair, 2012; Collis & Strijker, 2004; Fink, Rokklaer, & Schrey, 2007; Geschwind, Söderlind, & Magnell, 2015; Heywood, 2005; Jenni, 2009; Knowles et al., 2012; Mutter & Pruett, 2011; Osborne & Hennessy, 2003; Peraya et al., 2012; Strijker, 2004). En las empresas, los cursos y los recursos de aprendizaje que involucran conocimientos genéricos normalmente se subcontratan, mientras que los cursos y materiales sobre conocimientos del sector o de la empresa se crean normalmente en la propia empresa (Collis & Strijker, 2004; Strijker, 2004).

El aprendizaje electrónico o *e-learning* desempeña un papel importante en la organización y optimización de actividades de enseñanza y aprendizaje. Es un concepto general que designa el uso de tecnologías electrónicas para proporcionar información y facilitar el desarrollo de habilidades y de conocimientos (ASTD, 2012). El aprendizaje combinado o *blended learning*, también llamado aprendizaje híbrido o integrado (Koller, Harvey, & Magnotta, 2006), es el aprendizaje que mezcla diversas actividades o eventos, incluyendo aulas presenciales, aprendizaje síncrono por Internet y aprendizaje a ritmo individual. En las universidades se usa el aprendizaje en línea para organizar cursos y debates de clase (Ubell, 2010) sirviéndose de sistemas de gestión de aprendizaje y sus herramientas asociadas (Borondo, Benito, & Losada, 2014; Papathanassiou, Pistofidis, & Emmanouilidis, 2013; Sorensen, 2013). En las empresas, además de su escalabilidad y flexibilidad que consiguen reducciones de costes (disponibilidad en cualquier momento y lugar), se aprecia que la aplicación de tecnología sirve para acortar las sesiones en el aula (Collis, Bianco, Margaryan, & Waring, 2005) mediante el uso de tutoriales (Ubell, 2010). Se sabe que el desarrollo de Tecnologías de Información y Comunicaciones (TIC) y los contenidos para aprendizaje electrónico hechos a medida son caros, debido al uso de tecnología, a las actividades adicionales de gestión de proyectos y a las actividades añadidas de formación en estrategias de diseño, herramientas, procesos y estándares (Gagne, Wager, Golas, & Keller, 2005).

1.2. Modelos de colaboración universidad-empresa en el campo de la educación en ingeniería

Definimos la Colaboración Universidad-Empresa (CUE) en educación en ingeniería como una asociación entre una o varias IES y una o varias organizaciones de negocios, que tiene como propósito proporcionar soluciones de aprendizaje formal a sus respectivas comunidades de aprendices. Hay ocho formas principales en las que las IES y las empresas cooperan. Ordenadas de más común a menos son: colaboración en Investigación y Desarrollo (I+D), movilidad de estudiantes, comercialización de los resultados de I+D, aprendizaje permanente, desarrollo e impartición de programas de estudios, emprendimiento, gobernanza y movilidad de profesorado. Se ha descubierto que entre las principales barreras a una CUE productiva está la falta de profesorado con conocimiento profundo de la industria y experiencia en el negocio (Board, 2012).

2. TRABAJO EMPÍRICO

Se considera necesario desarrollar los conocimientos en la universidad y la empresa sobre Diseño de Materiales Educativos (DME) para guiar a los instructores de ambos entornos durante el diseño de material educativo, enriquecido mediante la combinación de las perspectivas académica y empresarial.

2.1. La investigación

Este proyecto de investigación tiene como objetivo estudiar los métodos de DME para el diseño de recursos digitales de aprendizaje que podrían apoyar el aprendizaje combinado tanto en el mundo académico como en la industria. Como se detallará después, la investigación no va dirigida a validar hipótesis en condiciones controladas, ni a validar relaciones de causa y efecto ni a predecir fenómenos, sino que va dirigida a explorar y generar principios educativos directamente a partir de observaciones fundamentadas sobre prácticas innovadoras en el mundo real.

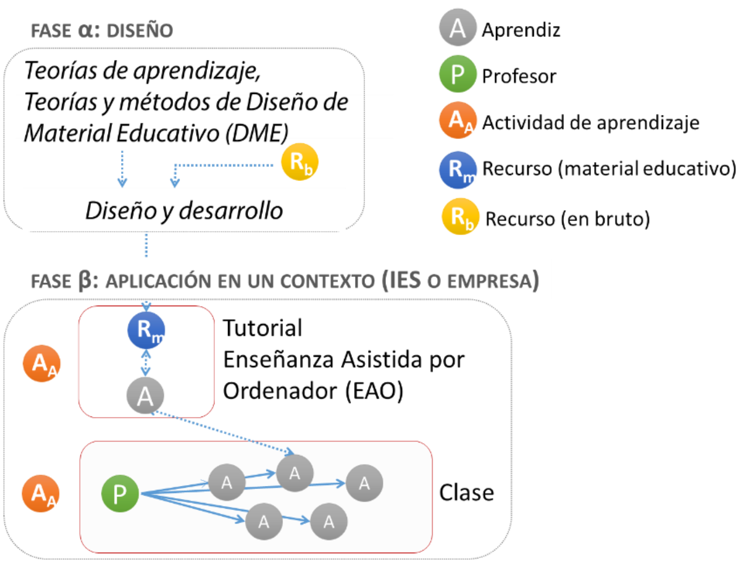


Figura 1. El estudio empírico: diseño de recursos educativos para aprendizaje combinado en una IES y empresa

Como se muestra en la Figura 1, se considera que el aprendizaje es combinado cuando el aprendiz tiene acceso a estas dos actividades de aprendizaje:

- Enseñanza Asistida por Ordenador (EAO), para el autoaprendizaje asíncrono, y
- Clase tradicional guiada por un profesor (personal docente o instructor).

El estudio se hace sobre doce cursos combinados: siete en IES, cuatro de formación empresarial interna y uno de formación impartido en un instituto de investigación. En total, el estudio completo incluye 182 aprendices, de los cuales 151 son estudiantes y 31 empleados. Doce profesionales participaron en la investigación, lo que representa 150 años de experiencia profesional acumulados y 73 de docencia. La investigación se ha realizado sobre muestras pequeñas y útiles.

2.2. Descripción del problema

La pregunta global de la investigación es: ¿cómo podemos diseñar recursos de aprendizaje, específicamente que usen multimedia, para garantizar su uso efectivo en dos contextos diferentes e identificados, el mundo académico y la industria? En particular, dichos materiales y la práctica de diseño asociada deberían ayudar a solventar la necesidad de soluciones asequibles durante una crisis económica, la necesidad de que el conocimiento circule entre el mundo académico, los investigadores y la industria para innovar y crecer económicamente, y la necesidad de desarrollar habilidades profesionales para una gestión satisfactoria de la CUE.

El proyecto de investigación tiene como objetivo articular un modelo entre universidad y empresa para el aprendizaje combinado en la formación de ingenieros. Se usarán observaciones fundamentadas y sus implicaciones teóricas para incrementar el conocimiento de la influencia de los contextos académico y corporativo en el diseño de material educativo para el aprendizaje combinado. En particular, el interés principal estará en los factores que influyen el diseño, la aplicación y el uso de un recurso de aprendizaje común al mundo académico y a la industria. La investigación tiene como objetivo responder las siguientes preguntas: 1) ¿qué diferencias existen en el uso del mismo recurso de aprendizaje entre el mundo académico y la industria en un aprendizaje combinado? 2) ¿qué factores influyen en la aplicación de un recurso de aprendizaje común en el mundo académico y en la industria? y 3) ¿cuáles son los factores principales a considerar para el diseño de dicho recurso de aprendizaje?

2.3. Metodología de investigación

La especificidad de este proyecto de investigación viene del hecho de que era improbable encontrar un proyecto existente que cumpliera las condiciones que permitirían investigar el sujeto en el contexto particular de la educación en ingeniería. Por consiguiente, se decidió aplicar prácticas educativas innovadoras y estudiarlas a la vez. Para ello se utiliza el modelo de la Investigación Basada en el Diseño (IBD), primero llamada "experimentos de diseño" por Brown (1992) y Collins (1992), después "investigación de desarrollo" (Van den Akker, 1999) o "experimento formativo" (Newman, 1992). Es un tipo de investigación (McKenney & Reeves, 2012) especialmente útil para diseñar y estudiar a la vez una solución innovadora para problemas educativos (Johri & Olds, 2011; McKenney & Reeves, 2012) (ver Appendix 1). Esta metodología IBD es flexible y trata de mejorar las prácticas educativas mediante iteraciones de análisis, diseño, desarrollo e implementación, basándose en la colaboración entre investigadores y profesionales, en situaciones del mundo real, y generando principios de diseño y teorías que tengan en cuenta el contexto y puedan ser útiles para el trabajo de otros (Cohen, Manion, & Morrison, 2011; Newman, 1992; Wang & Hannafin, 2005). Usando IBD se realizó un módulo de aprendizaje electrónico sobre Geoestadística, en entornos reales y en colaboración con instructores de la industria y profesores de la universidad. El módulo, un tutorial que el estudiante sigue a su ritmo en línea, está pensado para ser completado por los aprendices antes de una clase tradicional en la universidad o antes de la formación en la empresa (Figura 1).

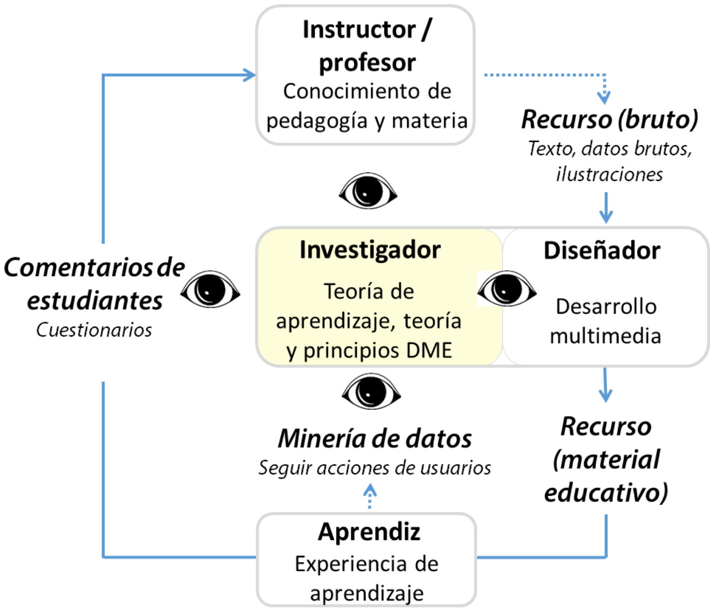


Figura 2. La investigación se hace sobre las intervenciones

El módulo ha sido refinado repetidas veces siguiendo el proceso de diseño. La investigación se ha realizado sobre las intervenciones, es decir, directamente sobre los métodos usados para diseñar el recurso educativo (McKenney & Reeves, 2012) y su utilización (Figura 2).

En la investigación participaron dos universidades (IFP School y ETSIM), tres empresas (Repsol, Geovariances, Beicip-Franlab) y un instituto de investigación (IGME). Usaron el tutorial en sus cursos y formación, los profesores y aprendices rellenaron cuestionarios, algunos de los instructores fueron entrevistados y otros hicieron una reseña detallada del módulo. Además, tres profesionales (Total, IFPEN) reseñaron el módulo y completaron los cuestionarios.

La Tabla 1 detalla las muestras disponibles para el estudio. La Fase I corresponde al ciclo de "prototipo" (McKenney & Reeves, 2012). El prototipo se probó con 79 estudiantes y 7 empleados. Tras esta primera aplicación con éxito, se hicieron pequeños ajustes de diseño y se mejoró el sistema de recogida de datos. De hecho, se mejoró el sistema de rastreo para recopilar las interacciones de los usuarios y se revisaron los cuestionarios con la ayuda de profesionales del campo del aprendizaje electrónico, del campo de la educación en ingeniería y del campo de la investigación en educación en ingeniería.

Tabla 1. Grupos y datos recogidos para el estudio (muestreo)

Fase	Código de curso	Institución	Número de aprendices	Número de usuarios		Comentarios de aprendices		Comentarios de instructores
				N	%	N	%	
I	1	Empresa A	7	6	86	7	100	1
	2	Universidad A	22	14	64	6	15	1
	3	Universidad A	19	13	68			
	4*	Universidad A	18	3	17	0	0	
	5	Universidad A	13	3	23	1	8	
Total			79	39	49 %	14	18 %	2
II	6	Empresa A	7	7	100	7	100	1
	7	Universidad A	30	30	100	27	90	1
	8	Universidad A	42	29	69	24	57	
	9	Empresa B	6	4	67	4	67	1
	10	Instituto A	6	5	83	6	100	1
	11	Empresa C	5	5	100	5	100	4
	12	Universidad B	7	7	100	5	71	1
Total			103	87	84 %	78	76 %	9

*opcional: disponible para consulta en línea, pero no formaba parte de un curso combinado

La fase II corresponde al segundo mesociclo, llamado "análisis y reflexión" (McKenney & Reeves, 2012). Es la fase de evaluación del estudio que corresponde a las pruebas empíricas que se hacen con el diseño avanzado. Cubre siete cursos combinados, tres en IES y cuatro cursos de formación profesional, incluyendo uno realizado en un instituto de investigación. El estudio incluye a 103 aprendices, de los cuales 79 son estudiantes y 24 empleados, distintos de los de la fase de prototipo.

2.4. Diseño del material de aprendizaje

Para realizar la investigación se diseñó un tutorial de aprendizaje electrónico sobre Geoestadística. Este módulo hace una introducción a los principios básicos de la Geoestadística y a su aplicación al modelado de yacimientos geológicos. El recurso de aprendizaje se creó originalmente para satisfacer las necesidades de educación en ingeniería y formación en la industria del petróleo y gas. Los aprendices reciben una introducción a los conceptos más importantes, siempre de forma visual e interactiva. El módulo se compone de cuatro capítulos, llamados “spatial analysis”, “spatial correlation”, “spatial estimations” y “spatial simulations”. El módulo se diseñó pensando en una duración de unos 40 minutos, aunque se ha observado que los aprendices interesados pueden pasar más de una hora y media, especialmente resolviendo los ejercicios. El módulo se puede modificar para adaptarse a la estructura del curso en la organización que lo use. Por ejemplo, en una formación de empresa el módulo se dividió en dos submódulos (o pistas). La “pista 1” cubría los dos primeros capítulos, “spatial analysis” y “spatial correlation”, mientras que la “pista 2” cubría los capítulos posteriores, “spatial estimations” y “spatial simulations”. Cada pista debía ser completada antes de cierto día de las sesiones de formación. El módulo incluye cinco ejercicios basados en Excel™, que se refieren a un único conjunto de datos de treinta puntos, y dos ejercicios interactivos y autoevaluados, integrados en el módulo. Además hay dos exámenes puntuados, uno al final del capítulo 2 y otro al final del capítulo 4. El módulo es compatible con SCORM™ en las versiones “1.2” y “2004”. Para su realización y alojamiento se ofrecen varias posibilidades: o bien alojado en un sistema de gestión de aprendizaje MOODLE™ dedicado, o alojado en el sistema de gestión de aprendizaje de la propia empresa. Se usa un sistema de seguimiento que permite acceder a información general como el día y hora del intento, el tiempo utilizado en completar el módulo, los resultados de los exámenes y el momento exacto de cada acción del usuario en el módulo. Cada vez que un aprendiz usaba el módulo toda la información sobre dicho uso se enviaba al instructor o profesor por la mañana, antes de comenzar la clase.

La Geoestadística, que es la disciplina del conocimiento sobre la que trata esta situación de aprendizaje, fue fundada por el profesor Georges Matheron en los años cincuenta. Es un campo de la ciencia dedicado a la aplicación de la estadística a conjuntos de datos espaciales o espaciotemporales. Permite interpretar la continuidad espacial y la incertidumbre. Como el curso es una introducción a la Geoestadística, es muy probable que sea la primera vez que los aprendices descubren las herramientas analíticas específicas que utiliza.

2.5. Métodos de recogida de datos

Para el estudio se dispuso de datos cuantitativos y cualitativos que fueron recogidos mediante cuestionarios, entrevistas semiestructuradas y el sistema que se usaba en línea para seguir las interacciones de los usuarios.

Resultó útil hacer cuestionarios piloto para recoger comentarios de los usuarios durante la fase de prototipo. Esta respuesta inicial informó tanto al instructor como al diseñador de aprendizaje electrónico (que también era el investigador) sobre la experiencia del usuario y las fortalezas y debilidades del diseño original. Los cuestionarios para la fase principal del estudio (fase II) fueron diseñados con la ayuda de un miembro del profesorado, un profesor de metodologías de investigación y herramientas de diagnóstico en la educación de la Facultad de Educación de la Universidad Complutense de Madrid. Además, la validez y fiabilidad de las preguntas fue revisada por seis profesionales del campo del aprendizaje electrónico (Consultoría en Educación para el aprendizaje electrónico, TU Delft; Instituto de Ciencias de la Educación, Universidad Politécnica de Madrid), del campo de la educación en ingeniería (Departamento de Formación y Aprendizaje, KU Leuven; Estructuras Aeroespaciales y Mecánica Computacional, TU Delft), y del campo de la investigación (Investigación de Educación en la Industria de Fabricación, Universidad de Cambridge). Se decidió que el cuestionario para aprendices sería anónimo para animar a los aprendices a participar y maximizar la tasa de respuestas, especialmente por la pequeña cantidad de aprendices de empresa. Al inicio del estudio se hicieron entrevistas para entender las prácticas, actitudes y valores de la gente respecto a la enseñanza, al aprendizaje, al conocimiento sobre temas relevantes científicos y de ingeniería y al aprendizaje en el que se emplea tecnología. Las entrevistas eran parcialmente estructuradas y se grabaron en audio. Demostraron ser particularmente útiles para familiarizarse con la disciplina y sus correspondientes prácticas de enseñanza. Destacaron que el uso de software profesional es común en la enseñanza de Geoestadística, dada su base en el procesamiento de datos. A partir de la fase II se recogió información sobre la experiencia del usuario. En cada intento de cada usuario se grababan los instantes exactos de cada interacción: al empezar el módulo, al acceder a cada subcapítulo, al abrir una pregunta basada en Excel™ y en todos los ejercicios integrados y respuestas a exámenes.

3. RESULTADOS DE LA INVESTIGACIÓN Y ANÁLISIS

Este capítulo describe primero los resultados de investigación recogidos respecto a la reseña del módulo realizada por los profesores y a la utilización del módulo por parte de los aprendices. En la segunda parte se construye un modelo de aprendizaje combinado en educación en ingeniería basado en las observaciones y resultados de la investigación.

3.1. La perspectiva de los profesores

En total, un gerente de formación en Geociencia y once instructores de Geoestadística respondieron al cuestionario, de los cuales dos eran personal docente de universidades y nueve eran formadores de la industria.

Desde la perspectiva de los profesores se pueden obtener las siguientes observaciones respecto a los temas investigados. Primero, respecto al uso del aprendizaje electrónico, los resultados muestran que el mismo recurso ha sido usado con éxito en el mundo académico y en la industria, y sigue en uso. De hecho, dos compañías y una IES aún emplean el recurso en sus cursos de Geoestadística. Se observó que el recurso de aprendizaje se usa de forma diferente según el profesor y según la estructura del curso. Además, la aplicación de esta actividad de aprendizaje adicional modificó las prácticas de enseñanza.

Segundo, hay varios factores que influyen en la aplicación de un recurso de aprendizaje común en el mundo académico y en la industria. El hecho de que la actividad se dirija como un proyecto de investigación puede haber contribuido a la participación de tantos interesados, reduciendo el efecto de la competencia y de la protección de la propiedad intelectual que de otro modo podrían haber afectado a dicha participación. Otro factor para la aplicación del aprendizaje electrónico es el número de años de experiencia de los formadores. Cuanta más experiencia, menos dispuesto está el instructor a aplicar recursos de aprendizaje electrónico. Aunque no sea estadísticamente significativo dado el pequeño tamaño de la muestra, los resultados hasta ahora sugieren que esta reticencia viene de ideas preconcebidas y resistencia al cambio de las prácticas de formación. Es más, los formadores experimentados piensan que los empleados no tienen tiempo para el aprendizaje electrónico. Al considerar la posible aplicación de recursos creados por la CUE, los formadores creen que su institución tiene las conexiones adecuadas para desarrollar dicha CUE y no creen que la diferencia de cultura entre universidad y empresa sea un obstáculo para que se produzca esta colaboración.

Por último, respecto al diseño de un recurso de aprendizaje común, se observa que, aunque los profesores pueden ser formados en DME, no usan ningún marco particular. Una metodología de DME específica podría ser útil para guiar la CUE en educación en ingeniería. Los instructores creen que la CUE ayuda a obtener perspectivas diversas y contribuye a enriquecer el contenido de enseñanza. En particular, los instructores consideran que la industria puede proporcionar casos de la vida real para que el aprendizaje sea auténtico. Sin embargo, no está claro cómo se introduciría este material en el recurso de aprendizaje.

3.2. La perspectiva de los aprendices

Primero, respecto al uso de aprendizaje electrónico para el aprendizaje combinado, el recurso fue utilizado por el 84 % de los aprendices durante 69 minutos de promedio. Esta duración es mayor que el tiempo estimado de uso para el que se diseñó el módulo (40 minutos) y mayor también que el tiempo que los aprendices están preparados para dedicarle (46 minutos) de promedio. Los estudiantes usaron el recurso electrónico durante la tarde y el fin de semana (93 %) y en casa (78 %). Los empleados usaron el recurso electrónico en horas de trabajo (59 %) y en el lugar de trabajo (68 %). Los empleados parecen dedicar más tiempo a los ejercicios y menos a los exámenes que los estudiantes. Estos datos no son representativos al tratarse de una muestra pequeña. Los resultados del examen fueron similares.

Segundo, hay varios factores que influyen en la aplicación de un recurso de aprendizaje común en el mundo académico y en la industria. La diferencia de edad entre estudiantes (la mediana es entre 23 y 25 años) y los empleados (35 a 39 años) podría tener efecto sobre el uso. Se comentó que los empleados se sentían menos cómodos con las funciones de Excel™, por ejemplo.

Los estudiantes no perciben la aplicación directa de lo que aprenden tanto como los empleados en sus actividades diarias. El 57 % de los estudiantes pueden estimar que harán uso en el futuro de lo que aprendan, mientras que en el caso de los empleados es el 68 %. Sin embargo, sería correcto decir que incluso esa tasa en estudiantes es alta. Se podría explicar por el hecho de que los estudiantes estaban inscritos en un máster especializado relacionado con el campo de la Geología.

Los empleados dicen que no es fácil dedicar tiempo al autoaprendizaje. No obstante, no se ha establecido una relación con el nivel de dedicación al autoaprendizaje, con el tiempo de uso del módulo, que es ligeramente mayor que para los estudiantes, ni con la satisfacción global (variables independientes).

Finalmente, respecto al diseño de un recurso de aprendizaje común, los estudiantes son más jóvenes que los empleados y podrían tener menos referencias anteriores que pueden influir sobre la asimilación de nuevos conocimientos. Aunque, en el contexto de este estudio, se imparte una clase introductoria que disminuiría este efecto, siendo un material nuevo para todos.

Los estudiantes y los empleados estiman que su tiempo de preparación para el estudio por cuenta propia es de 46 minutos y se observa que los empleados tienen una tolerancia muy baja a las actividades duplicadas.

La satisfacción es una consecuencia de la percepción de haber aprendido algo. Cuanto más creen los aprendices que han aprendido, más satisfechos están. Se ha visto que la capacidad de hacer que los estudiantes estén listos para la preparación de las clases es una consecuencia de la percepción de estar aprendiendo, de la exhaustividad del módulo y de la utilidad percibida de lo que se está aprendiendo.

3.3. El modelo de tres factores y la diferencia entre aprendices académicos y empresariales

En el contexto de este estudio el interés se centra en determinar el grado de relación entre los ítems como indicadores de la actitud del aprendiz hacia el módulo de aprendizaje electrónico y, más generalmente, hacia el aprendizaje combinado. Decidimos realizar un Análisis Factorial Exploratorio (AFE) para comprender mejor la estructura de los datos disponibles en el contexto de este estudio. Se identificaron tres conjuntos de variables que representan tres factores relacionados con la "percepción del aprendizaje", las "expectativas sobre el aprendizaje electrónico" y lo que llamamos "persistencia en el tiempo". Para comprender mejor las diferencias entre universidad y empresa, se hicieron pruebas de comparación adicionales entre las medias de las puntuaciones de los factores para las dos poblaciones. No hay una diferencia significativa entre las universidades y las empresas respecto a la percepción del aprendizaje ni a las expectativas sobre el aprendizaje electrónico. Sin embargo, los empleados puntúan alto en el tercer constructo llamado "persistencia en el tiempo", que se relaciona con el tiempo y la dedicación a aprender. Este constructo incluye la capacidad de imprimir el contenido del módulo. Esta petición significa que se espera poder usar el material en el futuro. De hecho, el instructor de la compañía A dijo que algunos aprendices llegaban a clase con la documentación del módulo y algunas anotaciones en ella.

Además, esta variable latente incluye la petición de revisar los ejercicios en clase, lo que valida la práctica empleada en la compañía A, en la que el instructor tomó la decisión de revisar los ejercicios en clase para cumplir las expectativas de los aprendices. También se obtuvo en este constructo el tiempo previsto para aprender por parte de los alumnos. Esta variable representa el tiempo previsto de preparación y es un indicador del deseo de aprender.

3.4. Un modelo universidad-empresa para el aprendizaje combinado en la educación en ingeniería

El modelo universidad-empresa para el aprendizaje combinado en la educación en ingeniería es una visión simplificada del potencial de la CUE en la educación en ingeniería. Su objetivo es ayudar a articular una metodología sólida de DME para el aprendizaje combinado en la educación en ingeniería.

Primero, se define la "contextualización" como una situación en la que el aprendiz necesita enmarcar un problema para activar la elaboración cognitiva generativa. La "contextualización" no es una actividad por sí misma sino que caracteriza a la transición desde la teoría a la aplicación del conocimiento. Las actividades para la "contextualización" serían diseñadas conjuntamente por el personal de la universidad y de la empresa. Estas actividades sirven para desarrollar la capacidad del aprendiz para superar situaciones difíciles. Segundo, en el caso de esta investigación, el enfoque de aprendizaje combinado se caracteriza como un modelo educativo que combina el autoaprendizaje, usando el tutorial de Geoestadística, y el aprendizaje colectivo dentro de la clase. Se tienen en cuenta dos tipos distintos de conocimiento para hacer la distinción entre autoaprendizaje y aprendizaje colectivo: el conocimiento declarativo y el conocimiento tácito. Se considera que el autoaprendizaje se apoya en gran medida en el conocimiento que ha sido hecho explícito por otras personas (conocimiento declarativo o información). Por otro lado el aprendizaje colectivo se nutre de múltiples fuentes de conocimiento informal que llevaría mucho tiempo formalizar (conocimiento tácito).

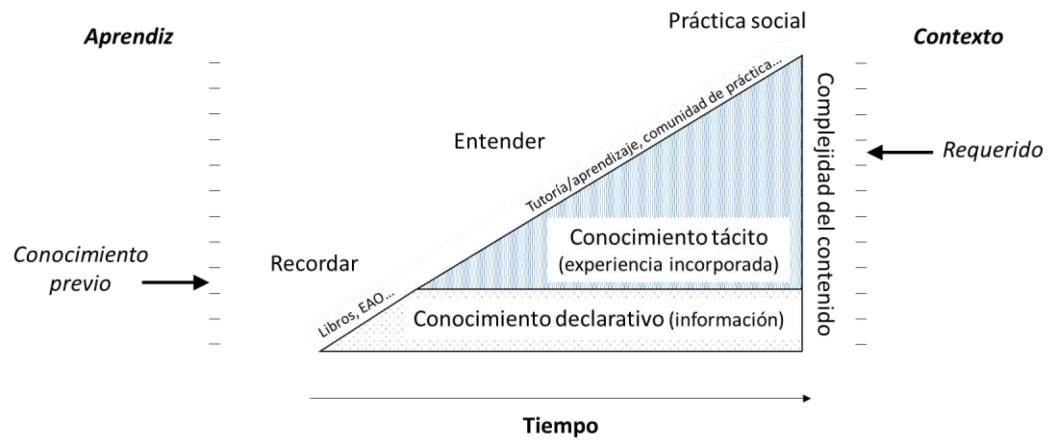


Figura 3. Vista cronológica del aprendizaje combinado en la educación en ingeniería (centrada en el aprendiz).

Se usó la Figura 3, un modelo de aprendizaje de referencia basado en la distinción entre conocimiento declarativo y tácito, para construir la Figura 4, el modelo universidad-empresa para aprendizaje combinado en la educación en ingeniería. El nivel requerido por parte del alumno depende de las expectativas trazadas por la autoridad institucional.

En la Figura 4 se representan dos sistemas diferentes universidad-empresa que pueden servir de ejemplo. El primer sistema muestra la universidad y la empresa como sistemas independientes, por oposición al caso que corresponde al estudio de investigación, en el que la universidad y la empresa se solapan.

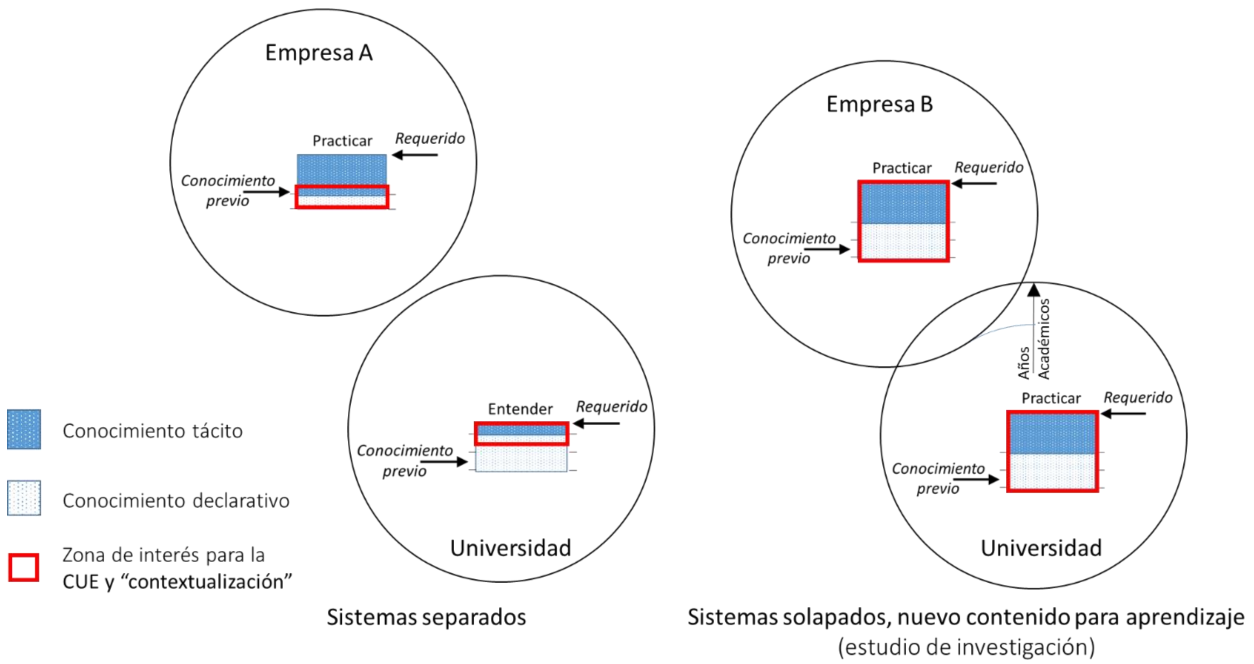


Figura 4. Modelo universidad-empresa para el aprendizaje combinado en la educación en ingeniería.

El modelo universidad-empresa para el aprendizaje combinado en la educación en ingeniería introduce el concepto de la zona de interés para la CUE y la "contextualización", que corresponde a la posibilidad de diseñar recursos de aprendizaje comunes al mundo académico e industria. Está formada por la porción de conocimiento declarativo y tácito que son necesarios para que se produzca el aprendizaje.

4. CONCLUSIONES Y PERSPECTIVAS

Los resultados de la investigación realizada desde el modelo de la Investigación Basada en el Diseño (IBD), permiten determinar los principales factores que influyen en el diseño y aplicación de un recurso común de aprendizaje entre el mundo académico y la industria para el aprendizaje combinado en la formación de ingenieros. En particular, tres preguntas son abordadas:

1. ¿Es el recurso de aprendizaje usado de manera diferente dentro de la academia y la industria?
2. ¿Cuáles son los factores que influyen en la aplicación de un recurso de aprendizaje común en el mundo académico y en la industria?
3. ¿Cuáles son los factores principales a considerar para el diseño y aplicación de dicho recurso de aprendizaje?

En primer lugar, considerando el uso específico del e-learning entre la universidad y la industria, es importante reconocer que el mismo tutorial electrónico ha sido aplicado con éxito en una formación mixta en ambos contextos. A día de hoy, dos compañías y una escuela de ingenieros continúan usando el recurso en sus programas de formación en Geoestadística. Con ello se muestra que en estos casos la teoría del aprendizaje multimedia, desarrollada por Mayer (2009), describe principios que son relevantes para que un aprendizaje efectivo ocurra, sin distinción entre los estudiantes y los profesionales. Además, se ha observado que los profesionales (llamados "empleados" en el estudio) están dispuestos a dedicar y dedican tanto tiempo al módulo de aprendizaje electrónico como los estudiantes. También se ha observado que los profesores encontraron creativas las ideas de integrar la nueva actividad digital en su curso. La influencia va en los dos sentidos. Por un lado, el curso influye en la manera en la que el tutorial ha sido impartido. A modo de ejemplo, un programa de formación de tres días requirió separar el módulo para su entrega en dos ocasiones. Por otro lado, la introducción de una nueva actividad de aprendizaje (e-learning para el autoaprendizaje) influyó en la forma de impartir el curso. Por ejemplo, uno de los profesores usó los resultados de los ejercicios para comenzar su formación reforzando varios conceptos. También se ha recogido que las capturas de pantalla del módulo o el módulo de aprendizaje en sí se utilizaron durante la clase, para explicar algunos conceptos con las ilustraciones interactivas del módulo, o simplemente para revisar ejercicios.

En segundo lugar, algunos factores influyen en la aplicación de recursos electrónicos comunes. Un aspecto importante es la disponibilidad de los usuarios para completar el módulo. Los profesionales declaran que no tienen tiempo y algunos instructores piensan que los profesionales no tienen tiempo para el auto-aprendizaje en línea. Sin embargo, los resultados muestran que los profesionales dedican tanto tiempo al módulo de aprendizaje electrónico como los estudiantes. En consecuencia, la queja de los profesionales debe ser interpretada como una llamada a una mayor consideración a fin de tener más tiempo, especialmente durante la jornada de trabajo (cuando se completan las actividades de formación en línea), en lugar de una señal de baja participación. Como se explica desde la teoría del aprendizaje situado, los empleados están sujetos a la influencia de su contexto profesional y personal. En contraste con los estudiantes que dedican de manera voluntaria la mayor parte de su tiempo a aprender, los empleados tienen que alcanzar sus objetivos profesionales definidos en términos de rendimiento de trabajo a los que se suman responsabilidades y compromisos para conciliar con la vida familiar. Otro factor importante que influye en la introducción del e-learning es la disposición de los instructores a utilizar nuevos métodos de enseñanza. Teniendo en cuenta a los profesores e instructores, diversos niveles de interés han sido observados al aplicar el modulo de aprendizaje electrónico en un curso. Se ha medido que los instructores más experimentados generalmente no tienen la intención de utilizar el e-learning en sus cursos. Resulta interesante indicar que estos instructores han argumentado que los profesionales no tienen tiempo para el aprendizaje en línea...

En tercer lugar, en el momento de diseñar programas de instrucción, los cuales incluyen recursos de aprendizaje comunes para la academia y la industria, los diseñadores deben tener en cuenta algunos aspectos adicionales. A pesar de la falta de tiempo, sujeto a queja, los profesionales no sólo completan las actividades de auto-aprendizaje como muchos de los estudiantes, sino que también solicitan su revisión colectiva durante la clase. Se ha observado también la tendencia a imprimir el documento del e-tutorial y hacer anotaciones sobre el mismo antes de ir a clase. De acuerdo con la AFE y el modelo de tres-factores de actitud de los aprendices ante el aprendizaje electrónico, la diferencia más significativa encontrada entre los estudiantes y profesionales es la expectativa de los empleados para un enfoque integrado y global entre las actividades de aprendizaje, con el objetivo de revisar los ejercicios, y de practicar. Este hallazgo se ajusta a los principios de aprendizaje de adultos descritos por Knowles, Holton, and Swanson (2012) que ponen en manifiesto la necesidad de los adultos de aplicar los conocimientos en el contexto de situaciones de la vida real.

Para terminar, se midió una relación positiva entre la satisfacción de los alumnos y la necesidad de material exhaustivo. Sin embargo, el propósito principal del aprendizaje antes de la clase no es ofrecer información exhaustiva y completa sobre un tema, sino, más bien, preparar a los estudiantes para asistir a actividades colectivas. Por consecuencia, es importante no considerar sólo la satisfacción global de los alumnos con el fin de evaluar la eficacia de la actividad de auto-aprendizaje. A modo de ejemplo, los estudiantes están significativamente más satisfechos con el e-learning. Esto conduce a la pregunta de si el valor del aprendizaje es el mismo para los estudiantes y los empleados, y de su alineación con las expectativas trazadas por la autoridad institucional. Ya que los profesionales están más interesados en la aplicación práctica de los conocimientos, se sostiene que el auto-aprendizaje, por sí solo, es menos proclive a satisfacer plenamente las expectativas de los profesionales.

Curiosamente, se encontró que los maestros y profesores no siguen ninguna metodología de diseño instruccional en particular. Como consecuencia, la construcción de un modelo constituye la base para establecer un marco para el desarrollo de los principios de diseño de materiales educativos en la universidad y las empresas. Como resultado, la colaboración directa de los miembros de la facultad con instructores corporativos permitiría la circulación de conocimientos entre la investigación y la industria, entre la educación inicial y continua, y los estudiantes se beneficiarían de los conocimientos científicos y técnicos avanzados conectado a desafíos reales de la industria. También permitiría desarrollar una cultura de colaboración y un entendimiento intercultural de tal manera que los colaboradores de la universidad y las empresas aprenderían a trabajar juntos. Por lo tanto, este tipo de principios de diseño ayudarían a desarrollar soluciones rentables mediante inversiones compartidas en el desarrollo de soluciones de educación en línea; a favorecer la circulación del conocimiento entre la academia, la investigación y la industria, con la difusión del conocimiento de la investigación, el aprendizaje profesional en Ciencia, Tecnología, Ingeniería y Matemáticas (CTIM) y a desarrollar profesionales con las habilidades especiales para gestionar las actividades de múltiples organizaciones para la gestión exitosa de la CUE.

A partir de los resultados de la investigación, un modelo para la formación combinada en la educación de ingenieros (ver Figura 4) fue elaborado, el cual incluye factores individuales, contextuales y relacionados con la información. La información ha sido compartida en el conocimiento declarativo y tácito que se considera que es la separación entre lo que se puede aprender en base a su propio ritmo y lo que se aprende en un entorno colaborativo. Este modelo es útil para hacer un juicio sobre el potencial de la CUE en la educación y la formación. La CUE se considera necesaria en el diseño de lo que se denomina en el presente documento situaciones de “contextualización” donde el alumno es retado y necesita enfrentar un problema. Como se mencionó anteriormente, la zona de interés para la CUE depende de la relación universidad-empresa frente a una práctica social particular. Esta colaboración para la instrucción es recomendada en ambientes donde los estudiantes y los profesionales tienen la misma necesidad de aprender nuevos conocimientos. Este es el caso cuando la industria y los estudiantes universitarios tienen que aprender los conocimientos basados en la investigación o el desarrollo de las prácticas sociales relacionadas con un sector industrial en particular.

En la investigación, los alumnos desarrollan sus habilidades para modelar yacimientos de hidrocarburos con herramientas Geoestadísticas. Esta práctica implica el uso de aplicaciones informáticas profesionales. La CUE para el diseño instruccional es válido en este campo por dos razones principales relacionadas con la “contextualización”. En primer lugar, los usuarios tienen que entender los conceptos teóricos en Geoestadística con el fin de enmarcar sus objetivos y desarrollar los flujos de trabajo pertinentes; y en segundo lugar, la ciencia es moderna (creada en la década de los 50’s) y continuamente se beneficia de mejoras en las aplicaciones informáticas y los cálculos con el fin de apoyar métodos de simulación avanzados. Como consecuencia, la práctica social está influenciada por el más reciente desarrollo de herramientas.

Además de la “contextualización”, la oportunidad para la CUE también proviene del interés de hacer el aprendizaje en ciencia e ingeniería atractivo. Curiosamente, no se ha encontrado ningún obstáculo para la CUE en la formación, sin embargo, argumentamos que la CUE no forma parte de las prioridades institucionales en la formación.

Para futuras investigaciones sobre CUE en la formación de ingenieros, se propone investigar la relación entre la naturaleza del conocimiento (tácito / declarativa, formal / informal) y los sistemas de enseñanza en el mundo académico y la industria. De hecho, esta investigación abre nuevas preguntas sobre el impacto de la naturaleza de la información sobre la disposición de la enseñanza en las universidades y las empresas. Proponemos profundizar las circunstancias, las formas, las ventajas e inconvenientes de hacer que el conocimiento tácito se convierta en información declarativa y formal en la universidad y en la empresa.

SUMMARY

1. THEORETICAL FRAMEWORK

In knowledge societies, University-Business Collaboration (UBC) in Engineering and Design are seen as a prevalent contributor for the provision of high quality education and qualifications, for the generation of innovation and economic growth.

1.1. Engineering Education

In the *Encyclopedia Britannica* (2016), engineering is defined as "the application of science to the optimum conversion of the resources of nature to the uses of humankind". In a global and knowledge-driven economy, it is considered that the transformation of knowledge into products, processes, and services is critical to competitiveness, long-term productivity growth, and the generation of wealth (Duderstadt, 2010).

In the late 1960s, new types of university and higher professional institutions emerged in Europe and included profession-oriented curricula to address the needs of the local industry (Christensen & Newberry, 2015; Collis & Strijker, 2004; Jonassen, 1999). The analysis of the three components of the didactic triangle, namely the teacher, the learner and the content, allows to draw a comparison of practices in Higher Education Institutions (HEI) and corporations. First, students and employees have different and similar dispositions for learning depending on their experience. Whereas mature learners are self-driven and are aware of their learning style, prior knowledge might make new learning more difficult to happen (Knowles et al., 2012). For both populations, teaching should be of sufficient intellectual challenge to motivate the learner (Heywood, 2005; Mayer, 2009) and authentic learning seems to be beneficial for learning to happen (Aubrun & Colin, 2015; Heywood, 2005; Knowles et al., 2012). Considering teaching and the instructional resources used at HEIs, the practice depends on the kind of embedding context at university. In the liberal model, teachers have full responsibility, while in the research model teaching is considered to be of relatively low value; and in the service model faculty develops, maintains and cultivates professional relationships (Alpay & Verschoor, 2014; Brémaud & Boisclair, 2012; Collis & Strijker, 2004; Fink et al., 2007; Geschwind et al., 2015; Heywood, 2005; Jenni, 2009; Knowles et al., 2012; Mutter & Pruett, 2011; Osborne & Hennessy, 2003; Peraya et al., 2012; Strijker, 2004). In corporations, courses and Learning Resources (LR) that involve generic knowledge are frequently outsourced; whereas courses and materials with domain-specific and corporate-specific knowledge are generally created in house (Collis & Strijker, 2004; Strijker, 2004).

E-learning is playing a major role in organizing and optimizing teaching and learning activities. E-learning is a general concept that describes the fact of using electronic technologies to deliver information and facilitate the development of skills and knowledge (ASTD, 2012). Blended learning, also called hybrid or integrated learning (Koller et al., 2006) describes learning that mixes various event-based activities, including face-to-face classrooms, synchronous online learning, and self-paced learning. In universities, online learning is used to organize courses and class discussion (Ubell, 2010) with the help of learning management systems and their associated tools (Borondo et al., 2014; Papathanassiou et al., 2013; Sorensen, 2013). In corporations, in addition to scalability and flexibility for cost reduction purpose (anytime, anyplace), technology application is seen as an opportunity to shorten the classroom session (Collis et al., 2005) through the use of tutorial content (Ubell, 2010). Information and Communications Technology (ICT) development and specific tailor-made e-learning contents are known to be expensive due to the utilization of technology, further project management activities and extra training activities for design strategies, tools, processes, and standards (Gagne et al., 2005).

1.2. University-Business Collaboration Models in the Field of Engineering Education

We define UBC in Engineering Education (EE) as a partnership between one or many HEIs and one or many business organizations, with the purpose of delivering formal learning solutions among the respective communities of learners. There are eight main different ways in which HEIs and business cooperates, ordered from the most usual to the less common, give: collaboration in Research and Development (R&D), mobility of students, commercialization of R&D results, lifelong learning, curriculum development and delivery, entrepreneurship, governance, and mobility of academics. It has been found that among the main barriers to productive UBC is the lack of academics with a deep understanding of industry and business expertise (Board, 2012).

2. EMPIRICAL WORK

The development of a University-Business knowledge on instructional design is deemed necessary to guide instructors from both contexts in their design of enriched teaching content by bringing academic and business perspectives together.

2.1. The Research

The research project aims to study the Instructional Design (ID) methods for the design of digital learning resources that would support blended learning in both academia and industry. As will be detailed later, the research is not aimed at validating hypotheses under controlled conditions, nor to validate cause-and-effect relationships, nor to predict phenomenon. However, the aim is to induce instructional principles directly from grounded observation made from innovative practices in real world environments.

As shown in Figure 5, Blended Learning (BL) is considered where the learner gets access to the two following learning activities:

- Computer Based Training for asynchronous self-learning,
- Traditional class with the guidance of a teacher (teaching staff or instructor).

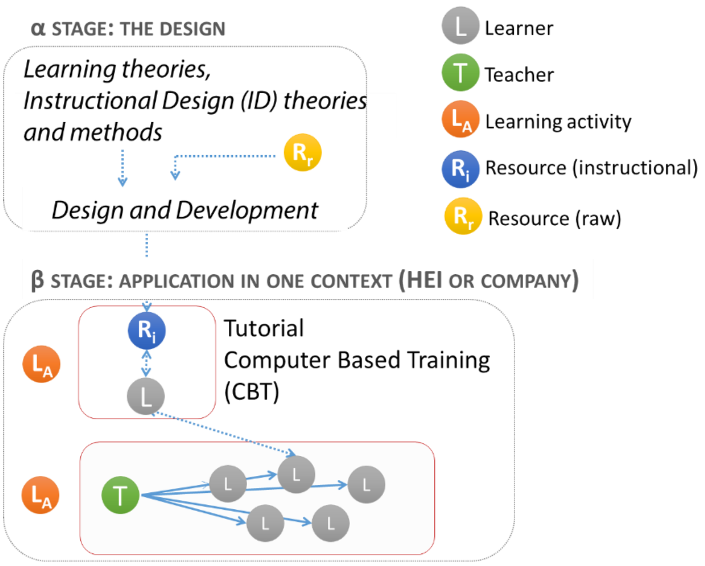


Figure 5. The research study: learning resources design for blended learning at HEI and company

The study covers 12 blended courses, seven at HEI, four in-house corporate trainings, and one training held in a research institute. In total, the whole study represents 182 learners, from which 151 students and 31 employees. Twelve practitioners participated in the research, representing 150 years of professional experience and 73 years of teaching. The research has been conducted on small and purposive samples.

2.2. Problem Statement

The global research question is: how can we design learning resources, specifically multimedia based ones, to guarantee their effective use in two different and identified contexts, namely academia and industry? In particular, such material and the associated design practice would help to address the need for cost effective solutions during economic downturn, the need to make knowledge circulation happen between academia, research and industry for innovation and economic growth, and the need to develop professional skills for successful UBC management.

The research project aims to articulate a University-Business model for Blended Learning in Engineering Education. Grounded observations and their theoretical implications will be used to foment the knowledge on the influence of the academic and corporate contexts on the design of instruction for blended learning. In particular, the main interest is in the factors influencing the design, the application and the usage of a common LR between academia and industry. The research aims to address the following questions: 1) is the same learning resource used differently within academia and industry for blended learning?; 2) what factors influence the application of a common learning resource within academia and industry?; and 3) what are the main factors to be considered for the design and application of such learning resource?

2.3. Research Methodology

The specificity of the research project comes from the fact that it was improbable to find an existing project matching the conditions that would allow investigating the subject in the particular context of engineering education. Consequently, it was decided to set innovative educational practices and to study them at the same time. Design Based Research (DBR), firstly called "design experiments" by Brown (1992) and Collins (1992), then "development research" (Van den Akker, 1999) or "formative experiment" (Newman, 1992), is a genre of inquiry (McKenney & Reeves, 2012) especially useful to design and study an innovative solution to educational problems at the same time (Johri & Olds, 2011; McKenney & Reeves, 2012) (see Appendix 1). DBR methodology is flexible and aims to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners, in real-world settings, and yields contextually-sensitive design principles and theories that can inform the work of others (Cohen et al., 2011; Newman, 1992; Wang & Hannafin, 2005). Using DBR, an e-learning module in Geostatistics has been engineered in real world settings and in collaboration with instructors from industry and teachers from university. The module, a self-paced tutorial, is aimed to be completed by learners before traditional class at university and before training in the company (Figure 5). The module has been refined iteratively along the design process. The research is conducted on interventions, that is to say, directly on the methods used to design the educational resource (McKenney & Reeves, 2012) (Figure 6).

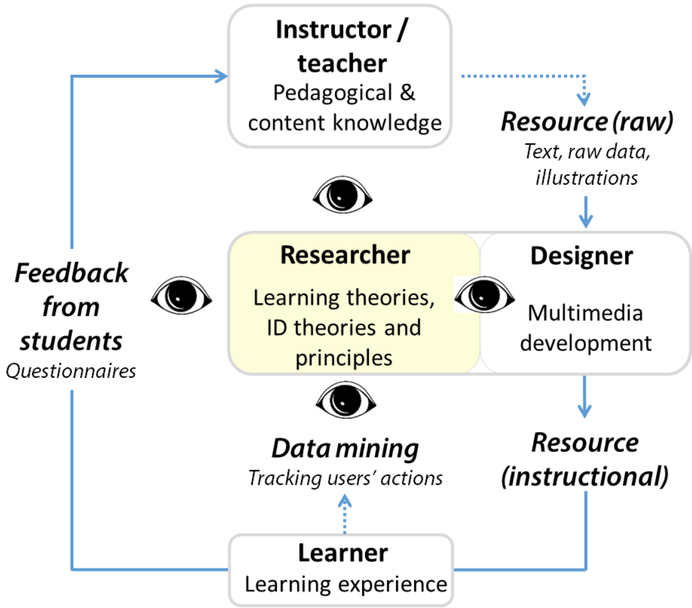


Figure 6. The research is conducted on interventions

Two different universities (IFP-school, ETSIM), three companies (Repsol, Geovariances, Beicip Franlab) and one research institute participated in the research (IGME). They used the e-tutorial for their courses and training, the teachers and the learners filled questionnaires, some of the instructors got interviewed while others made a detailed review of the module. In addition, three professionals (Total, IFPEN) reviewed the module and completed the questionnaires.

Table 2 shows the samples available for the study. Phase I corresponds to the "prototyping" cycle (McKenney & Reeves, 2012). The prototype was tested on 79 students and 7 employees. After this first successful application, small design adjustments were made and the data collection system was enhanced. Indeed, the tracking system to collect users' interactions was improved and the questionnaires were revised with the help of professionals from the e-learning field, from the EE field, and from the research field in EE.

Phase II corresponds to the second meso-cycle called "analysis and reflection" (McKenney & Reeves, 2012). It is the evaluation phase of the study corresponding to the empirical testing that is done with the advanced design. It covers seven blended courses, three at HEI and four professional trainings, including one training held at a research institute. The study represents 103 learners, from which 79 students and 24 employees, distinct from the prototyping phase.

Table 2. Groups and data collected for the study (sampling)

Phase	Course Code	Institution	Number of learners	Number of users		Feedback from learners		Feedback from instructors
				N	%	N	%	
I	1	Company A	7	6	86	7	100	1
	2	University A	22	14	64	6	15	1
	3	University A	19	13	68			
	4*	University A	18	3	17	0	0	
	5	University A	13	3	23	1	8	
Total			79	39	49%	14	18%	2
II	6	Company A	7	7	100	7	100	1
	7	University A	30	30	100	27	90	1
	8	University A	42	29	69	24	57	
	9	Company B	6	4	67	4	67	1
	10	Institute A	6	5	83	6	100	1
	11	Company C	5	5	100	5	100	4
	12	University B	7	7	100	5	71	1
Total			103	87	84%	78	76%	9

*optional: available online for consultation, was not part of a blended course

2.4. Design of the Learning Material

In order to conduct the research, an e-learning tutorial in Geostatistics was designed. The e-learning module gives an introduction to the main principles of Geostatistics and their application to geological reservoir modeling. The digital learning resource was originally created to address the needs of engineering education and training in the oil & gas industry. The learners receive an introduction to the most important concepts, all in an interactive and visual manner. The module is composed of four chapters, namely "spatial analysis", "spatial correlation", "spatial estimations" and "spatial simulations". The entire module has been designed to last around 40 minutes although it has been observed that committed learners could spend more than 1 hour and 30 minutes, especially on solving the exercises. The module can be modified to adapt the course structure within the "client's" organization. For instance, in the context of one corporate training, the module was split into two sub-modules (or tracks). "Track 1" covered the first two chapters: "spatial analysis" and "spatial correlation", whereas "track

2" covered the following chapters: "spatial estimations" and "spatial simulations". Each track had to be completed by a given day of the training session. The module includes five Excel™-based exercises, referring to one single dataset of 30 points and two interactive and auto-corrected exercises embedded in the module. In addition, there are two scored quizz, one at the end of chapter 2 and one at the end of chapter 4. The module is SCORM™ compliant in both the "1.2" and "2004" version. For its delivery and hosting, various possibilities were covered: either hosted on a dedicated MOODLE™ Learning Management System (LMS) or hosted on the corporate specific LMS. The tracking system in place allowed access to general information such as the day and time of the tentative, the time spent completing the module, the quizz' results, and the timestamp for each of the user's action in the module. Each time the module was used by a learner, all the information on the module usage was sent to the instructor or the teacher on the morning before the beginning of the lecture.

Geostatistics, which is the discipline or content knowledge in this learning situation, was funded by Professor Georges Matheron in the Fifties. Geostatistics is a science field interested in the application of statistics to spatial or spatiotemporal datasets. It enables the interpretation of spatial continuity and of uncertainty. Because the course is an introduction to Geostatistics, it is very likely that the learners discover the specific geostatistical analytical tools for the first time.

2.5. Data Collection Methods

Quantitative and qualitative data were available for the study and were collected via questionnaires, semi-structure interviews and the online system used to track users' interactions.

Pilot questionnaires resulted to be useful in order to collect users' feedback during the prototyping phase. This early feedback informed both the instructor and the e-learning designer (also the researcher) on the user experience and the strengths and weaknesses of the original design. The questionnaires for the main phase of the study (Phase II) have been designed with the help of a faculty member, a professor of research methodologies and diagnostic tools in education, at the Faculty of Education of the Complutense University of Madrid. In addition, the validity and reliability of the questions have been reviewed by six professionals from the e-learning field (Educational Consulting in e-learning / TU Delft, Instituto de Ciencias de la Educación / Universidad Politécnica Madrid), from the engineering education field (Teaching and Learning Department / KULeuven, Aerospace Structures & Computational Mechanics / TU Delft), and from the research field (Manufacturing Industry Education Research /

University of Cambridge). It was decided that the questionnaire for learners would be kept anonymous in order to encourage learners to participate and maximize the return rate, especially given the small population of corporate learners. At the beginning of the study, interviews were conducted in order to understand people's practices, attitudes and values regarding teaching, learning, scientific and engineering subject-matter knowledge and technology-enhanced learning. The interviews were semi-structured and audio recorded. They proved particularly useful to get familiar with the discipline and the corresponding teaching practices. It highlighted the fact that professional software usage is common in the teaching of Geostatistics, given its data processing nature. From Phase II, information was collected on the user's experience. For every attempt of each user, all timestamps corresponding to the interactions were recorded: at the start of the module, access to each sub-chapter, opening of an Excel™-based assignment, and all embedded exercises or quiz responses.

3. RESEARCH RESULTS AND ANALYSIS

Firstly, this chapter describes the research results collected regarding the module review done by the teachers and on the module usage by the learners. The second part builds a model of blended learning in EE based on the research observations and results.

3.1. The Teachers' Perspective

In total, one training manager in Geosciences and 11 instructors in Geostatistics answered the questionnaire, of which two were faculty members at university and nine were trainers from the industry.

From the perspective of the teachers, the following observations can be advanced considering the research questions. First, considering the e-learning usage, the results show that the same resource has successfully been used and is still in use within academia and industry. Indeed, two companies and one HEI still use the resources for their courses in Geostatistics. Interestingly, it was observed that the learning resource is used differently depending on the teacher and on the course structure. Moreover, the application of this additional learning activity for blended learning modified the teaching practice.

Second, the following factors do influence the application of a common learning resource within academia and industry. The fact that the activity was conducted as a research project may have contributed to the participation of so many stakeholders, lowering the effect of competition and Intellectual Property (IP) protection. Another factor for e-learning application is the number of years of experience of the trainers. The higher the experience, the less the instructor is willing to apply e-learning resources. Although it is not statistically significant given the small size of the sample, at this stage, it is suggested that this reluctance comes from preconceived ideas and resistance to change the training practices. Moreover, experienced trainers think employees do not have time for e-learning. Considering the applicability of such resources made by UBC, trainers believe their institution already have the right connections to develop UBC and they do not think that the difference of culture between university and business is an obstacle to UBC.

Finally, considering the design of common LR, it was observed that although teachers may be trained to ID, they do not use any particular framework. A specific ID methodology might be useful to guide UBC in EE. Instructors believe that UBC helps to get various perspectives and contributes to enrich the teaching content. In particular, instructors consider that industry can provide real life cases for authentic learning. However, it is not clear how this material would be introduced in the learning resource.

3.2. The Learners' Perspective

First, considering the e-learning usage for Blended Learning, the resource was used by 84% of the learners with a duration of 69 min on average. This duration is higher than the estimated time of usage the module was designed for (40 min) and higher than the time learners are prepared to dedicate on average (46 min). Students used the e-learning resource during the evening and the week-end (93%) and at home (78%). Employees used the e-learning resource during work hours (59%) and at the workplace (68%). Employees seem to dedicate more time on exercises and less time on quizz than the students (evidence from small sample size). The results of the quizz were similar.

Second, the following factors do influence the application of a common learning resource within academia and industry. The difference of age between students (median is 23 to 25 years old) and learners (35 to 39 years old for employees) might impact the usage. It has been reported that employees were less comfortable with Excel™ functions, for instance.

Students do not perceive the direct application of what they learn as much as employees in their daily activities. Fifty-seven percent of students can estimate future usage while 68% of employees can estimate future usage of what they learn. Yet, it is fair to say that the rate is still high for students. It could be explained by the fact that the students engaged in a specialized master related to the field of Geology.

Employees claim that it is not easy to dedicate time to self-learning. However, no relation has been established with the dedication level to self-preparation, the module usage time, which is slightly higher than for students, nor the global satisfaction (independent variables).

Finally, considering the design of common LR, students are younger than employees and might be subject to less anchoring. Nonetheless, in the context of the study, there is an introductory class which would lower the anchoring effect (new material for all).

Students and employees estimate preparation for self-study to be 46 minutes long and employees have very low tolerance to duplicated activities.

Satisfaction is a consequence of the perception to have learnt something. The more the learners think they have learnt, the more satisfied they are. It has been found that the capacity to make students ready (confident) for class preparation is a consequence of the perception of learning, the exhaustiveness of the module and the perceived usefulness of what is being learnt.

3.3. The Three-Factor Model and the Difference between Academic and Corporate Learners

In the context of the study, interest is focused on determining how well the items relate to each other in indicating learner's attitude towards the e-learning module and, more generally, towards blended learning. We took the initiative to run an Exploratory Factor Analysis (EFA) in order to better understand the structure of the available data in the context of the study. Three clusters of variables were identified that represent three factors related to the "perception of learning", the "expectations about e-learning" and the so-called "persistence over time". In order to better understand the differences between university and business, additional comparison tests were carried out between the means of factor scores for the two populations. There is no significant difference between university and business considering the perception of learning, neither the expectations about e-learning. However, employees rank high in the third construct called "persistence over time" which is related to time and dedication to learning. This construct includes the ability to print the module content. This request means that future use of the material is expected. Indeed, the instructor in Company A reported that some learners arrived at class with the handout of the module and some annotations on it. In addition, this latent variable includes the request to review the exercises in class, which validates the practice put in place at company A, where the instructor took the decision to review the exercises in class, addressing the expectations of the learners. Time dedication to learning (expected preparation time) was also part of this construct. This variable is a marker of learning desire.

3.4. A University-Business Model for Blended Learning in Engineering Education

The UB model for BL in EE is a simplified view of the potential for UBC in EE. Its aim is to help articulate sound ID methodology for BL in EE.

First, "contextualization" is defined as a situation where the learner needs to frame a problem in order to activate generative cognitive processing. "Contextualization" is not an activity by itself but rather characterizes the transition from theory to the application of knowledge. The activities for "contextualization" would be designed by university and business people together. These activities aim at developing the learners' capability to deal with challenging situations. Second, in the case of this research, the Blended Learning approach is characterized as an instructional system which combines self-learning, with the e-tutorial in Geostatistics, and collective learning within class. Two different types of knowledge are considered in order to make the distinction between self-learning and collective learning: declarative knowledge and tacit knowledge. It is considered that self-based learning relies extensively on knowledge which has been made explicit by other people (declarative knowledge or information). On the other hand, collective learning taps on multiple-sources of informal knowledge that would take a long time to formalize (tacit knowledge).

Keeping Figure 7 as a reference model of learning, based on the distinction between declarative and tacit knowledge, the UB model for BL in EE in Figure 8 was built. The contextual requirements level represent the expectations drawn on one's training by the institutional authority.

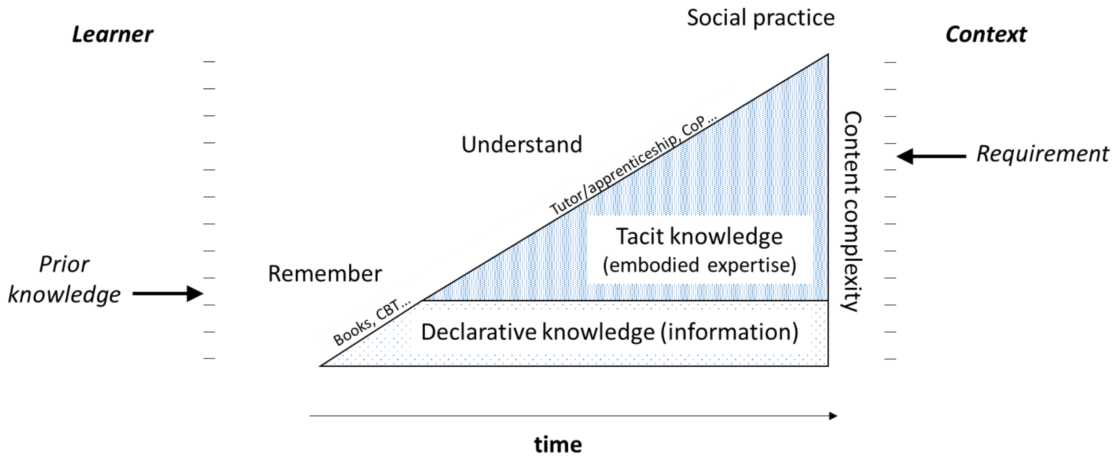


Figure 7. Chronologic View of Blended Learning in Engineering Education (learner centric).

In Figure 8, two different university-business systems are represented. The first system shows university and business as independent systems as opposed to the case corresponding to the research study where both university and industry are overlapping.

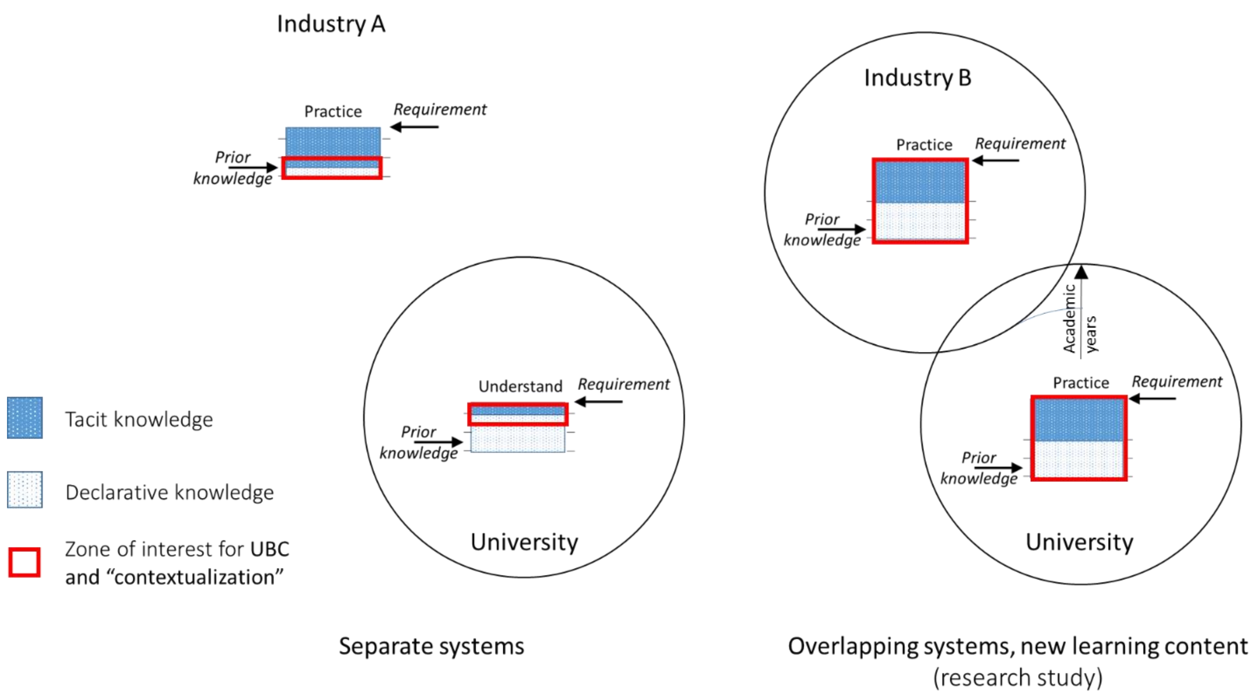


Figure 8. University-Business Model for Blended Learning in Engineering Education.

The UB model for BL in EE introduces the concept of the interest area for UBC and "contextualization" which corresponds to the potential to design common LR between academia and industry. It is composed of the portion of declarative and tacit knowledge necessary for learning to occur.

4. CONCLUSIONS AND PERSPECTIVES

This Design-Based Research aims at determining the main factors which influence the design and application of a common learning resource between academia and industry for Blended Learning in Engineering Education. In particular, three questions are addressed:

1) Is the same learning resource used differently within academia and industry for blended learning?

2) What factors influence the application of a common LR within academia and industry?

3) What are the main factors to be considered for the design and application of such learning resources?

First, considering the distinctive usage of e-learning between university and industry, it is of importance to recognize that the same e-tutorial has been successfully applied for BL in both contexts. Today, two companies and one HEI still use the resource for their teaching in Geostatistics. It is the illustration that multimedia learning theory, developed by Mayer (2009), describes principles which are relevant for effective learning to happen, with no distinction between students and professionals. In addition, it has been observed that professionals (called employees in the report) are ready to dedicate and do dedicate as much time to e-learning as students. Concerning the instructors, we observed creative ways of integrating the new learning activity in their course. The influence goes two ways. On the one hand, the course structure influences the way the e-learning tutorial is delivered. As way of example, a 3-day course program made it necessary to split the e-tutorial for its delivery in two times. The instructional delivery is polymorphic in the sense that a single learning resource can generate multiple chronological scenarios of usage. On the other hand, the introduction of a new learning activity (e-learning for self-learning) influences the class delivery. For instance, one teacher used the students' quizz results to start his course before reinforcing various concepts. Interestingly, screenshots of the module or the e-learning module itself were used during class, to illustrate some concepts with the interactive illustrations of the module, or simply to review exercises.

Second, some factors influence the application of common e-learning resources. One major aspect is the availability of the users to complete the module. Professionals claim they do not have time and some instructors think that professionals do not have time for self-learning online. However, employees do dedicate as much time to e-learning as students. As a consequence, the professionals' complaint should be interpreted as a call for more consideration in order to have more time, especially during their professional hour (when they complete e-learning activities) rather than a signal of low participation. In compliance with situated learning theory, employees are subject to the influence of their professional and individual contexts. In contrast with students who voluntarily dedicate most of their time to learning, employees have to reach their professional objectives defined in terms of working performance and often have busy personal life with social and family related commitments. Another prominent factor which influences the introduction of e-learning is the willingness of the instructors to use new instructional approaches. Considering both teachers and instructors, diverse levels of interest to apply e-learning to one's course have been observed. It has been measured that more senior instructors generally do not plan to use e-learning in their courses. Interestingly, they argued that professionals don't have time for e-learning…

Third, at the time to design instructional programs which include common learning resources for academia and industry, instructional designers should take into account some additional aspects. Despite a lack of time, subject to complaint, professionals not only complete the self-learning activities as much as students but even call for collective review during class. One observation has been their tendency to print the e-tutorial handout and make annotations on it before going to class. According to the EFA and the three-factor model of learners' attitude towards e-learning, the main significant difference found between students and professionals is employees' expectation for an integrated and global approach between the learning activities, with the aim of reviewing the exercises, and to practice. This finding complies with the principles of adult learning described by Knowles et al. (2012), which highlight the necessity for adults to apply knowledge in the context of real-life situations. To finish, we measured a positive relationship between learners' satisfaction and the need for exhaustive material. However, if considering that the primary purpose of learning prior to class is not to deliver exhaustive and complete information on a subject-matter but rather to prepare students to attend collective activities, special care is hence recommended not to consider only the learners' global satisfaction in order to evaluate the effectiveness of the self-learning activity. As way of example, students are significantly more satisfied with the e-learning. This leads to the question of whether the value of learning is the same for students and employees and of its alignment with the expectations drawn by the institutional authority. Since professionals are more interested in the practical application of knowledge, it is argued that self-learning, on its own, is less inclined to fully satisfy professionals' expectations.

Interestingly, it was found that teachers and instructors do not follow any particular Instructional Design methodology. As a consequence, the development of a model set the basis to establish an ID framework for the development of University Business ID principles. As a result, the direct collaboration of faculty members with corporate instructors would allow knowledge circulation between research and industry, between initial and continuing education, and students would benefit from advanced scientific and technical knowledge connected to real industry challenges. It would also allow to develop a collaborative culture and a cross cultural understanding as the contributors from university and business would learn to work together. Hence such design principles would help to develop cost effective solutions with shared investments for the development of e-learning solutions; make knowledge circulation happen between academia, research and industry with research knowledge dissemination, vocational learning in STEM and lower time-to-competency; and develop professionals with the special abilities to manage cross-organizational activities for successful UBC management.

From the research results, a model for BL in EE (see Figure 39) was built which includes individual, contextual and information-related factors. Information has been shared in declarative and tacit knowledge which is considered to be the separation between what can be learnt on a self-paced basis and what is learnt in a collaborative environment. This model is useful to make a judgement on the potential for UBC in education and training. UBC is deemed necessary to design what are called herein situations of "contextualization" where the learner is challenged and needs to frame a problem. As mentioned above, the interest zone for UBC depends on the UB relationship against a particular social practice. UBC for instruction is recommended in environments where students and professionals have the same need to learn new knowledge. This is the case when industry and university students have to learn research-based knowledge or to develop social practices related to a particular industrial sector. Considering the research, the learners developed their abilities to model hydrocarbon reservoir with geostatistical tools. This practice involves the use of professional software. UBC for ID is successful in this field for two major reasons related to "contextualization". First, the users need to understand the theoretical concepts in Geostatistics in order to frame their objectives and develop the relevant workflows, and second, the science is modern (created in the 1950s) and continuously benefits from software and calculation improvement in order to support advanced simulation methods. As a consequence, the social practice is influenced by the most recent tools development.

In addition to "contextualization", the opportunity for UBC also comes from the interest to make learning in science and engineering attractive. Interestingly, no obstacle for UBC in ID has been found, however, we argue that UBC is not part of the institutional priorities in training.

For future research on UBC in EE, we consider studying the relation between the nature of knowledge (tacit/declarative, formal/informal) and the instructional systems in academia and industry. Indeed, this research opens new questions on the impact of the nature of the information on the arrangement of instruction in universities and businesses. We propose to further analyze the circumstances, the forms, the advantages and disadvantages of making tacit knowledge become declarative in academia and industry.

1. THEORETICAL FRAMEWORK

In knowledge societies, University-Business Collaboration (UBC) in engineering and design are seen as a prevalent contributor for the provision of high quality education and qualifications, for the generation of innovation and economic growth. In a global and knowledge-driven economy, it is considered that the transformation of knowledge into products, processes, and services is critical to competitiveness, long-term productivity growth, and the generation of wealth (Duderstadt, 2010).

This first chapter is a review of the literature. University and Corporate educational settings are reviewed in order to understand both contexts and to identify the driving forces for UBC in Engineering Education (EE). The material under scrutiny stands at the junction of four fields, namely cognitive education, engineering & science, Higher Education Institutions (HEIs) and industry. Scientific and technical publications in the field of EE, Instructional Design (ID), Education and Technology (E&T), higher education and corporate training (see Figure 9) were reviewed. This chapter also aims to provide an overview of the current teaching and learning practices in EE within HEIs and corporations, along with the main UBC frames in engineering.

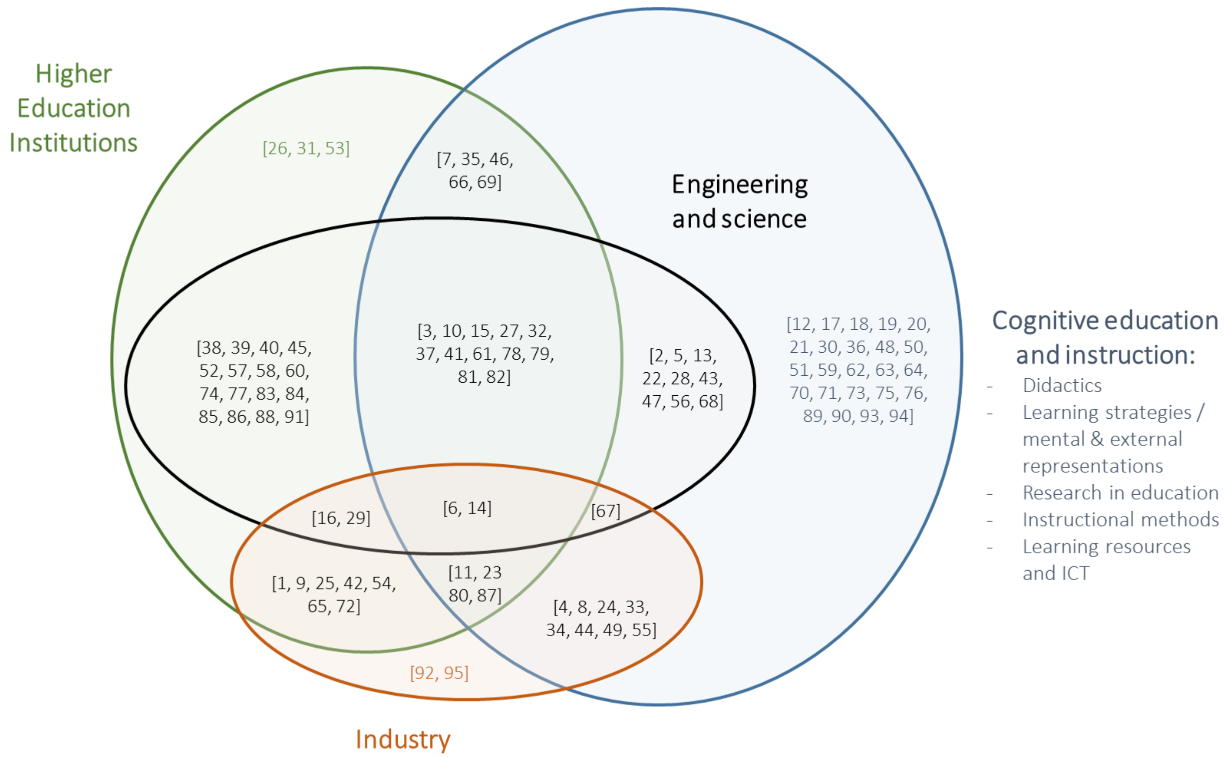


Figure 9. Literature sources by topic.

Before entering the specificity of engineering education, some major definitions on education, learning and training are recalled. Knowles et al. (2012) defines education as an activity "undertaken or initiated by one or more agents that is designed to effect changes in the knowledge, skill, and attitudes of individuals, groups, or communities". According to Mayer (2009), instruction refers to "the instructor's manipulations of the learning environment that are intended to promote learning" In the context of the research, cognitive learning is considered, that is to say, "the set of instructional methods that assist students in learning knowledge to be recalled or recognized, as well as developing students' understandings and intellectual abilities and skills" (Reigeluth & Moore, 1999).

According to Lord Dearing's National Committee of Inquiry into Higher Education, the role of higher education in a learning society is to inspire and enable individuals to develop their capabilities to the highest level, to increase knowledge and understanding, to serve the needs of the economy and to shape a democratic and civilized society (as cited in Laurillard (2002)). In turn, in companies, particularly in technical and creative jobs such as in engineering, training supports employees to reach their full potential capabilities, to develop their dispositions to learn (Knowles et al., 2012), and their practical knowledge (Gagne et al., 2005). Training programs are aligned with business strategies (Gagne et al., 2005), with the aim to bring about intended change to the organization performance (Gagne et al., 2005; Kessels, 1993). In this general context, imagining what Boisclair (Brémaud & Boisclair, 2012) called "the bridges between the places of research production and theoretical knowledge, and the world of emergence of practical and action knowledge", namely academia and industry, is taken into consideration.

1.1. ENGINEERING EDUCATION

In order to organize the discourse on EE, a comparison is drawn between university and corporate educational settings in EE with the help of the didactic triangle as shown in Figure 10. The didactic triangle is a representation of the student-teacher-content triad which goes back to the work of Johann Friedrich Herbart (1776-1841) (Jaako, 2014). For each context, this representation allows the consideration of the main components of the corresponding pedagogical system and their relationship: the teacher, the learner and the content. In HEIs and corporations, the teachers are the faculty members (teaching staff) and the instructors (trainers) respectively, while the learners are the students and the employees respectively.

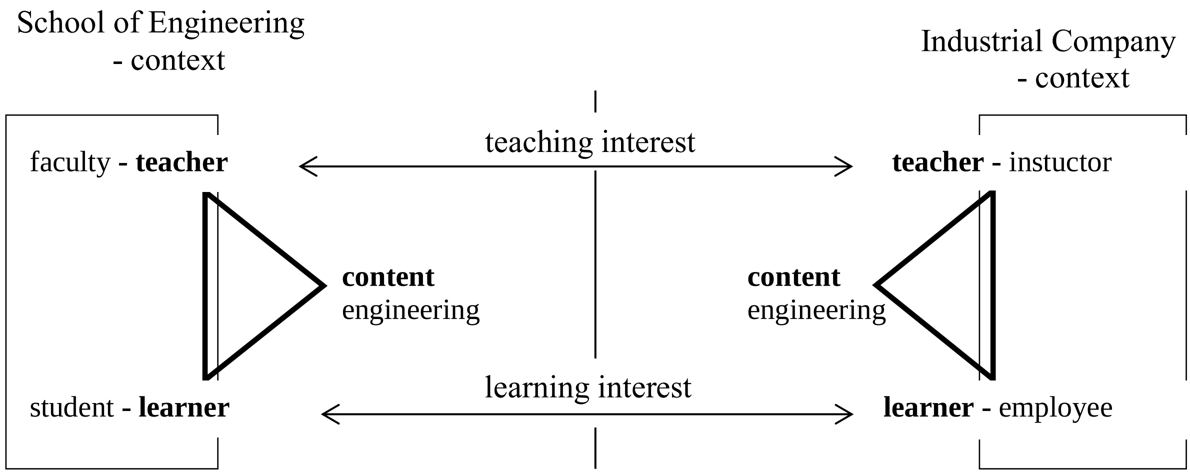


Figure 10. Comparison of academic and corporate educational settings using the didactic triangle.

As shown in the Figure 10, the faculty members and instructors share teaching interest in their respective fields whereas students and employees share learning interests. The aim is to understand if these interests hold similarities and complementarities in order to contemplate successful UBC in EE.

The following section studies the pedagogical content in both contexts. Here, "content" means the content to be learnt, that is to say, the object of study. In this case, the content is related to one subject matter in engineering or applied sciences.

1.1.1. Educational Systems in Europe and Curriculums in Engineering Education.

In the *Encyclopedia Britannica (2016)*, engineering is defined as "the application of science to the optimum conversion of the resources of nature to the uses of humankind". For Goldberg (2010), engineering is "the social practice of conceiving, designing, implementing, producing, and sustaining complex technological artefacts, processes, or systems". In a global and knowledge-driven economy, it is considered that the transformation of knowledge into products, processes, and services is critical to competitiveness, long-term productivity growth, and the generation of wealth (Duderstadt, 2010).

Engineering fields are diverse (see Table 3) as are engineering roles.

Table 3. Example of a classification of engineering disciplines with the related fields of science involved. Adapted from Donofrio, Sanchez, and Spohrer (2010).

Artifacts & Industries	**Eng. Discipline**	**Science**	**Fields + Mathematics**
Steam engines, machinery	Mechanical	Physics	Mechanics, materials
Generators, grid, appliances	Electrical	Physics	Electromagnetism (EM)
Crops, orchards	Agricultural & Bio	Biology	Cellular mechanisms
Computers, Info Tech (IT)	Computing machinery	Phys/Logic	EM, OR, Complexity/System dynamics (CSD), Algorithms
Reactors	Nuclear	Physics	Nuclear
Jets, rockets	Aerospace	Physics	Fluid dynamics
Medical instruments	Biomedical	All	Sensors, EM, TD
Bacteria, plants, animals	Genetic technology	Bio/Chem.	Genetics
Applications, websites	Software	Logic	Psych., Social, Econ, OR, CSD

1.1.1.1. Educational Systems in Europe

Martin Trow as cited in Christensen and Newberry (2015) noted that:

> "in Europe, the transformation of systems of elite higher education into systems of mass higher education took place from the 1960s and early 1970s onward. Prior to the 1960s, post-secondary education in Western Europe can be described as university-dominated. Higher education was the exclusive province of the university and university-level specialized colleges, including university-level engineering colleges. Vocational training in engineering, teacher training and nursing were not regarded as higher education and were offered by separate professional schools either to prepare for a specific occupation or to prepare for a profession.
>
> In the 1960s and early 1970s a transition from university-dominated systems to binary systems of higher education including engineering took pace in many European countries." (p. 36)

New types of institutions were created to deal with increasing numbers, a more diversified student body and a rapidly growing need for manpower in advanced industrial societies. These new institutions were called "universities of applied science", "university colleges", "institutes of technology" or "polytechnics" (Christensen & Newberry, 2015).

Guy Neave, as cited in Christensen and Newberry (2015), defined a set of objectives of these institutions, which were:

"created as an alternative to the autonomous university tradition in Europe. The objectives mentioned by Guy Neave are:

- Meeting the demands for vocational, professional and industrially based courses
- The creation of a separate sector of higher education outside the universities
- Greater public control to ensure continued responsiveness to social and economic demands of the locality
- Increased standing of vocational and professional education

In professional engineering education the objectives mentiones above would thus apply, by the time of their implementation, to British Polytechnics, French Instituts Universitaires de Technologie, so-calles IUTs" (and nested into universties), "German Fachhochschulen, Dutch Hogescholen, Belgian Hogescholen in the Flemish part of Belgium, Hautes Ecoles in the French part of Belgium, Hautes Ecoles Spécialisées in the French part of Switzerland, Ammatikorkeakoulou in Finland, Irish Institutes of Technology, so-called IoT's etc. The objectives are characterized by their work orientation and orientation towards the needs of the local community and industry for a skilled workforce to boost growth and competitiveness in the regional economy." (p. 37)

As cited in Delahousse and Bomke (2015),

"the evolution of higher education in Europe over the past 40 years has been marked by a double and opposite trend: on the one hand, practice-oriented institutions have turned to more science-oriented curricula; on the other hand, universities whose traditional mission is to deliver research-based knowledge have developed profesion-oriented curricula. In some countries, like Denmark, Germany, the Netherlands or Belgium, this has led to a number of institutional mergers either within the framework of universities or by the creation of larger non-university entities. This phenomenon is part of "an international trend that the difference between the university and the college sector has become blurred" according to Jens-Christian Smeby. Smeby also points out that in the field of professional education the "curriculum has moved from a craft model towards an academic model". Similarly, Raymond Bourdoncle first observes "the multiplication of professional university degrees, from the creation of IUTs in 1968 to the professional Masters in 2004" in France" (p. 71-72).

As cited in Christensen and Newberry (2015),

"British polytechnics were upgraded to university status in 1992. In Germany the gap between universities and Fachhochschulen narrowed down or simply eroded from 2001 to 2004 as the outcome of the Bologna process". Briefly put, the Bologna process refers to the attempt by the European ministers of higher education to create a European higher education area aiming at "greater compatibility and comparability of the systems of higher education" in order to "promote citizens' mobility and employability". The ultimate goal is to increase the international competitiveness of European higher education on a global scale (Bologna Declaration, 1999). At the core of the Bologna process was "the adoption of a system essentially based on two main cycles, undergraduate and gradute" –bachelor and master- (Bologna Declaration, 1999), as these were seen as generally accepted exit points for professional practice" (p. 40).

Regarding the Bologna process Lucena, Downey, Jesiek, and Elber (2008) and Uhomoibhi (2009) can also be refered to.

In France, the higher educational system in engineering offers students a 3-year engineering program after the completion of the 2-year preparatory program, the so-called "classes préparatoires aux Grandes Ecoles". Some engineering schools select students from a national or dedicated examination after the preparatory cycle, while others have their admission process open to university students (bachelor or master), and others have an integrated preparation course. The system is made up of non-university institutions called "Grandes Écoles" (elite schools), public or private, which were created in the eighteenth century for the oldest one and established as branches of the state. The Écoles Nationales Supérieures d'Ingénieurs (ENSI), created during the second half of the twentieth century, were formerly part of universities and are now either internal schools or autonomous institutions connected to a specific university. In 2000, the Polytech Group network was made up of thirteen engineering schools. These schools were created from local mergers between public engineering schools and professional university masters.

1.1.1.2. Curriculum in Engineering Education

Engineering discipline is organized around three pillars: theory, experimentation, and modelling & simulation. In academic engineering, some teachers argue that the separation of a curriculum into distinct applied science categories (silo thinking) prevents students from developing solving capabilities of open-ended problems (Heywood, 2005). As stated by Heywood (2005), instruction often filters out the complexity that exists in most applied knowledge domains, causing shallow understanding of domain knowledge to develop. Applied to design, it means that students cannot cope with ambiguous and complex situations (Heywood, 2005). In addition, teaching design differs from teaching engineering science-based content to students. Throughout higher education, there has been therefore an on-going emphasis towards the development of problem-solving capabilities, meta-cognitive skills, critical thinking (Collis & Strijker, 2004), together with an apprenticeship into a community of professionals (Sfard, as quoted in Collis and Strijker (2004). These approaches to teaching rely on constructivist principles of learning such as embedding learning in authentic contexts and social settings and providing opportunities for discovery learning and self-reflection (Jonassen, 1999).

As recalled by Heywood (2005), any effort to develop a single model curriculum is doomed to failure because it would have to satisfy so many diverse parties. Actually, according to Duderstadt (2010), different types of educational institutions and programs should prepare students for diverse roles such as: system engineers, master engineers, engineering scientists and engineering managers. Hence, as Sheppard and William stated (as quoted in Duderstadt (2010), new paradigms for engineering education are demanded to respond to the incredible pace of intellectual change and to address the 21st century's social, economic, environmental, and political challenges.

As a way of example, the master´s programs at the Faculty of Aerospace Engineering at Delft University of Technology is studied, whose design has been described by Saunders-Smits (2014). Indeed, Dr. Ir. Gillian N. Saunders-Smits, the Chair of Aerospace Structures & Computational Mechanics in the Faculty of Aerospace Engineering accepted an interview on the 9th of December, 2013. Semi-structured interviews were conducted with Dr. Ir. Gillian N. Saunders-Smits, Dr. Roeland de Bruker (teacher and assistant professor in Aerospace Structures & Computational Mechanics, who is leading research in the field of aeroelasticity and adaptive structures), and Linda Mebus (educational e-learning consultant at OC focus). OC focus is the Centre for Expertise in Education at TU Delft, in charge of assisting faculties and staff in their efforts to provide excellent education. One of the main tasks of OC Focus is supporting the implementation of ICT in education. OC Focus is project leader for a number of general TU Delft projects such as blended learning and online distance learning. At the time of the visit, an online master was under study.

As stated in TUDelft (2013), the profile of the Masters of Science graduates in Aerospace Engineering are described as T-shape professionals who are deep problem solvers in science, engineering, design and management, and are capable of interacting with and understanding specialists from a wide range of disciplines and functional areas (Figure 11).

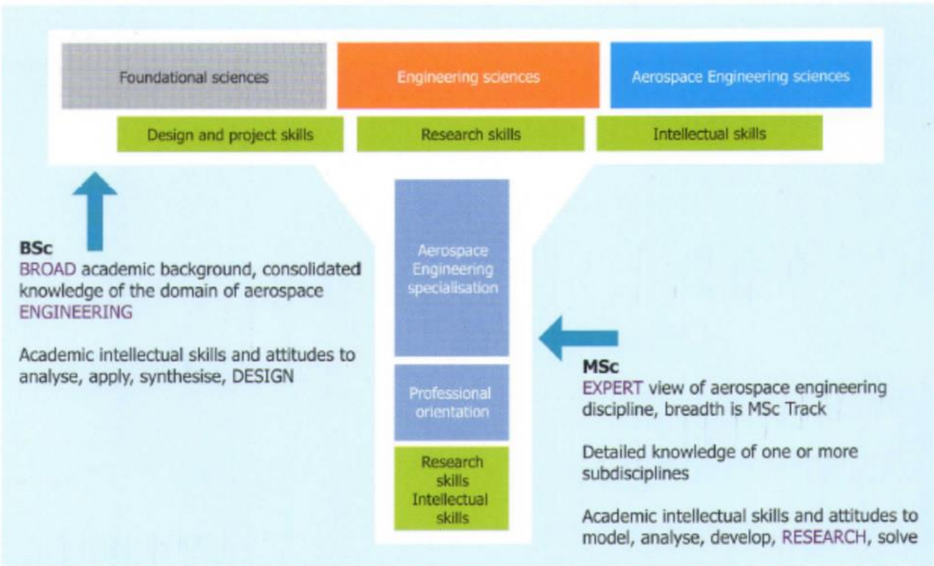


Figure 11. The T-Shape professional as the reference point for BSc and MSc Aerospace Engineering (TUDelft, 2013).

In particular, the BSc provides a broad academic background with a consolidated knowledge of Aerospace Engineering, combined with the development of general academic and engineering skills. The MSc provides an expert view of Aerospace Engineering with a focus on detailed knowledge of one or more sub-disciplines, together with the intellectual skills and attitudes needed to model, analyze, solve, experiment and research.

MSc Aerospace Engineering graduates are academic engineers who can apply their knowledge and skills to solve real-life practical problems and are prepared to develop technologies for innovation. Therefore, it was considered important that authentic research or innovative engineering problems and questions in the life of an engineer are identifiable subjects in the curriculum.

The generic outline of the tracks in MSc Aerospace Engineering is shown below (Figure 12). A track is a general field of Aerospace Engineering (discipline) and a profile is a refined direction within that field of expertise (subdiscipline). Five MSc tracks are offered for specialization: Aerospace Structures & Materials, Flight Performance and Propulsion, Aerodynamics and Wind Energy, Control and Operations, and Space Flight. The MSc has a common outline for all tracks: each comprises core, profile and elective courses, a master orientation project or literature study, an internship and the MSc thesis, all with a fixed study load (TUDelft, 2016).

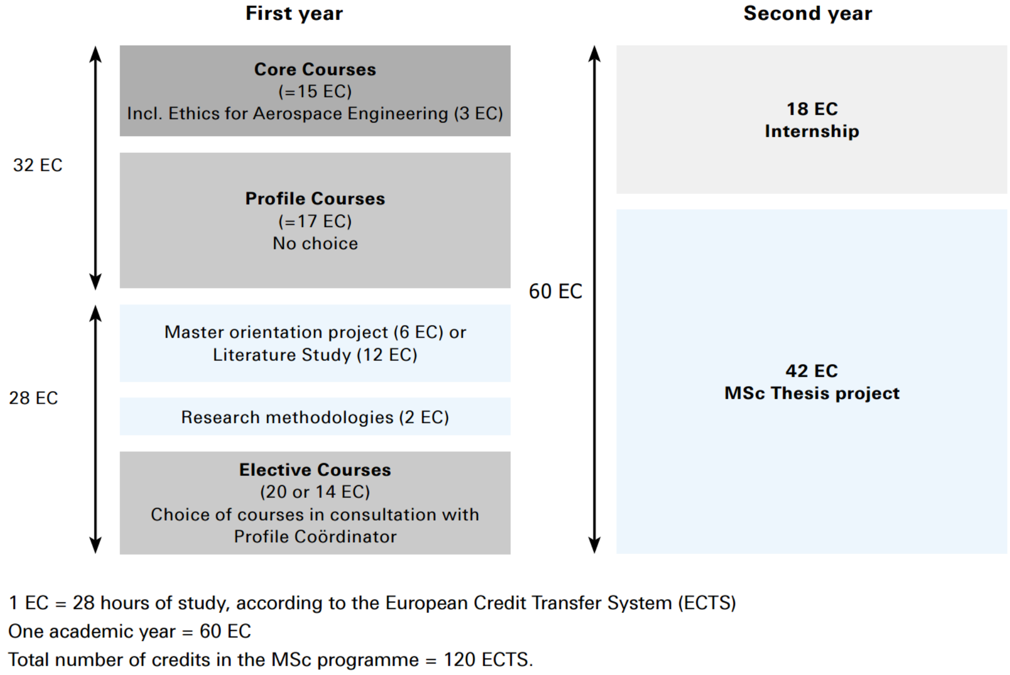


Figure 12. Curriculum in Aerospace Engineering in 2015-2016 (TUDelft, 2016). Standard outline of the Master's program.

As stated in TUDelft (2013), the core courses are obligatory for everyone enrolled on the track concerned. They enable the student to develop a broad view of its theme. All tracks include two common courses: Research Methodologies and Ethics for Aerospace Engineers, a non-technical module about personal integrity and awareness of the technical and societal implications of Aerospace Engineering.

The profile courses enable the student to develop a thorough and detailed knowledge on a particular subfield. They are obligatory for all students re-enrolled in that profile. The elective courses provide flexibility for the student to specialize in a particular area of expertise or to add multidisciplinary elements, repair educational deficiencies or address a personal interest. These courses are selected by the student in consultation with the MSc track coordinator, the profile adviser or a staff member who oversees the complete theme. Students can also fill part of the elective space by taking courses abroad. The master orientation project aims to explore the work of a project group, enabling students to familiarize themselves with a field of expertise and gain an introduction to independent research or expert design work on a day-to-day basis. This prepares them for the choice of their thesis subject. The literature study, on the other hand, is a preparatory research assignment directly related to the subsequent thesis subject. The three-month internship enables the student to acquire professional skills different from those taught in the classroom. The MSc concludes with the MSc thesis, an in-depth research or expert design assignment in the specific field of expertise chosen by the student. This project can be considered to be a capstone project (Ward, 2013). In preparing this, the student becomes an independent researcher receptive to lifelong learning. On top of the regular program, students can opt to add one of two extra annotations to their degree: Technology in Sustainable Development or Entrepreneurship.

The number of Master´s degrees awarded annually has risen from about 75 to about 200 between 2002 and 2012 (from around 280 to 485 for the BSc influx). Most students originate from BSc programs at TU Delft, with about two-thirds of them being BSc Aerospace Engineering graduates. Around 5 to 10 people come from the industry per year. Approximately 20% of students come from other Dutch institutions or from abroad. The ratio of Dutch to non-Dutch students is approximately 3:2. By the end of December 2012, the student-to-staff ratio, which is the total population of students registered on the BSc and MSc programs divided by the total full-time equivalent number of all permanent and temporary academic staff at the faculty, was 34. The institution has a target of 25. Finally, gender issue and under-representation of female students was taken into account. For instance, in 2013, only about 10% of the student population on the MSc in Aerospace Engineering were female (TUDelft, 2013).

Between 2002 and 2012, the dropout rate for BSc fluctuated from 14% to 42% after one year of study, from 23% to 40% after 2 years, and from 25% to 40% after 3 years.

The qualifications match the international ABET criteria and CDIO standards (Conceiving, Designing, Implementing and Operating as context for engineering education). According to the Initiative (2016), the CDIO™ INITIATIVE is an innovative educational framework for producing the next generation of engineers. The framework provides students with an education stressing engineering fundamentals set in the context of Conceiving — Designing — Implementing — and Operating (CDIO) real-world systems and products. Throughout the world, CDIO Initiative collaborators have adopted CDIO as the framework of their curricular planning and outcome-based assessment.

This section puts forward the diversity of engineering roles and higher educational systems in Europe. Besides, the fact that over the last decades, university and higher professional institutions tend to include both science-oriented curricula and profession-oriented curricula has been acknowledged.

1.1.2. Academic and Corporate Learners

This section aims to understand how the profiles of learners compare between university students and professionals from industry.

The attitudes and values learners hold depend on the stage of development they are at. According to Perry's post-Piagetian theory, development continues into adulthood and university should prepare students for self-directing and lifelong learning (Beston, Fellows, and Culver, as quoted in Heywood (2005). As a way of example, the "staged self-directed learning model" of Beston, Fellows, and Culver goes from the dependent stage, the interested stage, the involved one to the self-directed level (Heywood, 2005). Riding and Staley were particularly interested in the self-perception that students had of themselves as learners in relation to cognitive style and performance. They concluded from their research that students have to develop self-awareness of their style so that they can understand its appropriateness for the particular subject they are studying (Heywood, 2005). Besides, Culver and Yokomoto considered the relation of optimum academic performance to emotional intelligence in engineering education. They suggested that in flow, the human organism is functioning at its fullest capacity. When this happens, the experience is its own reward. For flow to be realized, the challenges and skills have to be equal (Heywood, 2005). The concept of flow is similar to the essential material described by Mayer (2009) in Multimedia Learning. Essential material is seen as the core information from the lesson that is needed in order to achieve the instructional goal. Mayer explains that the essential processing in both auditory and visual channels should be lower than the cognitive capacity of the learner. Indeed, it is argued that teaching should be matched to the readiness of the student for learning, but of sufficient intellectual challenge to motivate the student to want to move forward.

Considering the influence of prior experience, the role of the adult learner's experience has become an increasingly important focus area. Former experience creates biases that can influence new learning. There is a natural tendency to resist new learning that challenges existing mental representations (Heywood, 2005; Knowles et al., 2012). Consequently, a lack of prior experience is not necessarily a disadvantage for learning. According to Kalyug's findings (Mayer, 2009), instructional methods that are helpful for low-knowledge learners may not help or may even hinder high-knowledge learners. It is what he calls the expertise reversal effect. This effect might be related to what Mayer (2009) calls the "generative processing" which is the processing aimed at making sense of the material and organizing the incoming material into coherent structures and integrating these structures with each other and with prior knowledge. From Mayer's (2009) view, the essential processing and generative processing should be lower that the cognitive capacity of the learner.

In addition, as described by Heywood (2005), Culver and Sackman called growth experiences "marker events". In accordance with constructivist approaches, they argued that learning activities that have high levels of marker potential will involve the learner in activity based learning. Therefore, Culver argued that teachers have to provide opportunities for students to behave as engineers. "If one wants to be an engineer, one has to behave as an engineer". Similarly, Flammer advocated the use of case studies in order to give students "a flavor of the reality of engineering" (Heywood, 2005). In addition to motivational implication for university students, the use of real-life and authentic situations is also beneficial for adult learning (Knowles et al., 2012). Adults seem to learn best when new information is presented in real-life context. As a result, the experiential approach to learning, most effectively advanced by Kolb, has become firmly rooted in adult learning practice (Knowles et al., 2012). Social sciences research on professional and workplace learning, as the practice-theory perspective (as cited in Reich et al. (2015), allow to shift "the focus from the attributes of the individual learners (knowledge, skills and attitudes) to the attributes of the practice (interactions, materiality, opportunities and challenges)", that is to say, the context of real life situations. This perspective led HEI to provide role playing in EE (Aubrun & Colin, 2015).

From the theoretical standpoint, students and employees have different and similar dispositions for learning depending on their experience. Whereas mature learners are self-driven and are aware of their learning style, prior knowledge might make new learning more difficult to happen. For both populations, teaching should be of sufficient intellectual challenge to motivate the learner and authentic learning seems to be beneficial for learning to happen.

1.1.3. The Professor, the Instructor and Instruction

This section considers the role and teaching practice of teachers at HEI and instructors in corporations. Special focus is given on instructional resources and ICT. Bourdoncle and Lessard define three university models that influence the way of teaching (Brémaud & Boisclair, 2012): the first university model is the model of liberal education where knowledge acquisition makes people free from handwork. In this model, the university departments tend to be relatively closed, with a hierarchical ordering of status, with fairly rigorous structures for the provision of curriculum, and it is made up of scholars (Heywood, 2005). Therefore, in this scenario, teachers have full responsibility for making decisions regarding the content, methods, and sequence and assessment of learning (Collis & Strijker, 2004; Jenni, 2009; Knowles et al., 2012). In the second model, the research model, universities organize their research and knowledge production according to the structures of disciplinary sciences (Fink et al., 2007). In that case, vocational training is perceived as an application area of scientific knowledge. Teachers integrate their current research results into courses and the learning resources are their intellectual property (Collis & Strijker, 2004; Fink et al., 2007; Jenni, 2009). Some studies, such as Alpay and Verschoor (2014), are available on the faculty attitudes towards teaching in research-intensive universities and show that teaching is considered to be of relatively low value along with a low usage of the teaching experience to support research (Geschwind et al., 2015). The last model is the service university. In this model, HEIs serve the social advances and utilitarian knowledge. It assumes that intelligence works better at the junction of theory and practice. Faculty develop, maintain and cultivate professional relationships with their target industries (Mutter & Pruett, 2011). It is the case of French IUTs for instance.

The kind of teaching strategies and instructional resources used in HEI depend on the educational settings. Peraya et al. (2012) found three types of hybrid systems at universities centered on the teaching practices. In the first one, “la scène” (the stage) or the theatre metaphor, the teacher is the central character and acts. This scenario is characterized by text-based teaching resources and oral transmission. The second one, “l’écran” (the screen), symbolizes the introduction of ICT for illustration and information transmission purpose. However, the spectators remain passive before the screen. The last metaphor is the “cockpit”. The class is organized and managed so that ICT is integrated to the instruction.

At universities, the communities of practice made of teachers have distinct forms and mechanisms for the exchange and production of learning resources (Henry and Peraya as quoted in Jenni (2009)). The types of digital materials most used within a course are PowerPoint™ presentations, word-processed documents created primarily by the instructor, digital copies of scientific articles and, increasingly, digital resources available via the World Wide Web. In science, as stated by Hennesy (Osborne & Hennessy, 2003), teachers’ motivation to use ICT in the classroom is limited by a number of factors such as: the lack of time to implement technology, a limited access to reliable resources, a curriculum overloaded with content, no need to use technology for assessment, and a lack of guidance for using ICT to support teaching and learning. According to Strijker (2004), in the university context, reuse of learning resources is occurring, albeit in a personal-oriented way. In universities, it has been found that six main barriers prevent teachers from sharing their learning resources: the lack of collaborative culture at university, a possible loss of time, instructors' self-esteem and fear of judgment, preference to informal learning, need to avoid plagiarism, and the effort needed to work the layout (Jenni, 2009). In this respect, Barrère states that the individualistic culture among faculty members is more a consequence of the current working organization of instructors, organized around the classroom cell, rather than a shared and common disposition (as quoted in Jenni (2009)).

In knowledge societies, human capital is one of the most important assets of engineering companies. Human capital confers a competitive advantage to companies in order to innovate, adapt to market conditions, and anticipate changes. In companies, a large part of learning, around 80% according to Tough's and Cross' studies, is informal (McAndrew, 2010; Zimmermann, 2010) (see Figure 13).

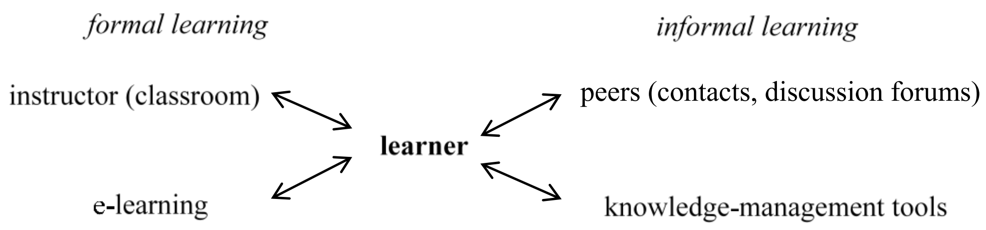


Figure 13. Formal and informal learning in companies.

Informal learning is defined by Livingstone as "any activity involving the pursuit of understanding, knowledge, or skill that occurs without the presence of externally imposed curricular criteria" (as cited in McAndrew (2010)).

Considering formal training, the course offer addresses business change and human resources development needs identified through competence-gap analyses (Collis & Strijker, 2004). Accelerating skills acquisition, by means of reducing the "time to competency", helps organizations better cope with changes in processes, products and organizational structures.

In the industry, the courses and LR that involve generic knowledge are frequently outsourced; whereas courses and materials with domain-specific and corporate-specific knowledge are generally created in-house (Armour, as quoted in Strijker (2004)). In-house course resources are corporate property and sharing and reusing resources is common (Collis & Strijker, 2004). Instructors generally use available digital media such as PowerPoint presentations, word-processed documents, copies of scientific articles. However, e-learning contents and, in particular, tutorials are usual. Indeed, what characterizes e-learning at companies is the transfer of traditional teaching to individual e-tutoring systems that allow remote study from the workplace or at home (Rossett et al., as quoted in Collis et al. (2005)). In Europe, tutorials, also called customized modules, remain the type of e-learning resource most used in that domain (CrossKnowledge, 2011).

Traditionally, organizations have handled learning in their training departments separately from the operational business. “Standard” courses were designed or purchased by the training departments and were booked by the business departments. Today, a corporate university is usually merged with the training department, having taken over their role (Zimmermann, 2010). Corporate Universities or Corporate Academies initially referred to centralized activities that enable the alignment of top managers’ capabilities with the companies’ strategy. Since then, technical campuses and universities of engineering have also emerged. While policy makers seek new ways to foster university-business collaboration, industries implemented training practices that remained in the corporate ecosystem, and even created their own privately held universities or academies, offering business training, technical training and corporate graduate programs. So far, it has been noticed that teaching practice and instructional resources, design and usage, especially in HEI, depend on the embedding context as defined in the Situated Cognition theory (Robbins & Aydede, 2009). In corporations, training resources are corporate property and their sourcing depend on the kind of knowledge involved (general or industry-specific). In addition, large companies created centralized Corporate Universities to promote a corporate culture development.

In this first section, a comparison has been drawn between HEI and corporations for the three main components of the didactic triangle. The coming section focuses on the use of technology for education and training.

1.2. Blended Learning and its Cost

This section defines what is an instructional resource, e-learning, blended learning, and the Multimedia Learning theory. It describes blended learning practice in HEI and companies, and details economic aspects related to e-learning development.

According to Puimatto, learning resources are information, documents, software, and database that enable the distribution, transmission and comprehension of learning concepts and contents (Jenni, 2009). Development can be made on the structure of instructional resources used by Gagné (2005). Instructional resources are associated with delivery methods, such as a teacher/instructor, computer, simulator, or actual system; instructional strategies, such as small group discussion, case studies, and mentoring; and instructional media, such as audio, video and film, text, photographs, animation, and graphics (Gagne et al., 2005)

Educational media proper do not influence the achievement of students; they permit the delivery and storage of instructional messages but do not determine learning (Gagne et al., 2005). Consequently, the principles of learning that apply in traditional education will of course apply equally to the design of technology-enhanced learning (Gagne et al., 2005; Heywood, 2005). Similarly, according to Mayer (2009) "Clark (2001) has eloquently argued that instructional methods cause learning, but instructional media do not cause learning. Similarly, Moreno and Mayer (2002) have shown that the same instructional methods have the same effects on learning regardless of whether the medium is a desktop computer, non-immersive virtual reality, or immersive virtual reality" (p.53). Mayer (2009) indicates that "multimedia messages that are designed in light of how the human mind works are more likely to lead to meaningful learning than those that are not".

E-learning is playing a major role to organize and optimize teaching and learning activities. E-learning is a general concept that describes the fact of using electronic technologies to deliver information and facilitate the development of skills and knowledge (ASTD, 2012). Blended learning, also called hybrid or integrated learning (Koller et al., 2006), describes learning that mixes various event-based activities, including face-to-face classrooms, synchronous online learning, and self-paced learning. The optimum choice and mix of these methods is based on the target audience, the content to be learned, and the availability of technologies (Gagne et al., 2005). It has been found that blended learning is a more effective social-constructivist approach of teaching and learning in comparison to traditional or virtual learning alone (Means, Toyama, Murphy, Bakia, & Jones, 2009).

Three Views of Multimedia

View	Definition	Example
Delivery media	Two or more delivery devices	Computer screen and amplified speakers
Presentation modes	Verbal and pictorial representations	On-screen text and animation
Sensory modalities	Auditory and visual senses	Narration and animation

Figure 14. The three views of multimedia according to Mayer (2009)

According to Mayer (2009), the theory of multimedia learning is “a cognitive theory of how people construct knowledge from words and pictures” (p.59), hence adopting the definition of multimedia based on the presentation-modes view (Figure 14). “Multimedia design can be conceptualized as an attempt to assist learners in their model-building efforts” (Mayer, 2009). Mayer (2009) enounced 12 principles of multimedia instruction:

1. Coherence Principle: “People learn better when extraneous material is excluded rather than included” (p.89).
2. Signaling Principle: “People learn better when cues that highlight the organization of the essential material are added” (p.117).
3. Redundancy Principle: “People learn better from graphics and narration than from graphics, narration and printed text” (p.118).
4. Spatial Contiguity Principle: “Students learn better when corresponding words and pictures are presented near rather than far from each other on the page or screen” (p.135).
5. Temporal Contiguity Principle: “Students learn better when corresponding words and pictures are presented simultaneously rather than successively” (p.153).
6. Segmenting Principle: “People learn better when a multimedia message is presented in user-paced segments rather than as a continuous unit” (p.175).
7. Pre-training Principle: “People learn more deeply from a multimedia message when they know the names and characteristics of the main concepts” (p.189).
8. Modality Principle: “People learn more deeply from pictures and spoken words than from pictures and printed words” (p.200).
9. Multimedia Principle: “People learn better from words and pictures than from words Alone” (p. 223).
10. Personalization Principle: People learn better from multimedia presentations when words are in conversational style rather than formal style” (p.242).
11. Voice Principle: “People learn better when narration is spoken in a human voice rather than in a machine voice” (p.242).
12. Image Principle: “People do not necessarily learn better when the speaker’s image is added to the screen” (p.258).

Gagné (2005) defined the term “affordances” as the properties or functions of technology that extend our learning and perceptual capabilities (Gagne et al., 2005). As suggested in Basque and Lundgren-Cayrol’s work (2002), the selection of technology and media according to their respective “affordance” within given instructional delivery strategies is preferred. The following part describes how technology is used in HEI and companies.

1.2.1. Blended Learning in Higher Education Institutions

In universities, online learning is used to organize courses and class discussion (Ubell, 2010) with the help of learning management systems like the Open Source MOODLE™

(Borondo et al., 2014; Papathanassiou et al., 2013; Sorensen, 2013), wikis (Hennig, Mertsching, & Hilkenmeier, 2015), planning tools such as Google Calendar Service™ (Sextos, 2014), collaborative tools such as Blackboard Collaborate™ for synchronous web conferencing between remote populations of students for instance (May, Wold, & Moore, 2015), Drive™ for collaborative work on shared online documents such as peer review (Dominguez et al., 2015) and YouTube™ for recorded lectures (Sextos, 2014). Online classes are made of learning activities with multimedia and interactive material (Comerford, 2014; Francis & Shannon, 2013; Papathanassiou et al., 2013; Sextos, 2014), simulation and modelling tools (Hockicko, 2015), exercises (Borondo et al., 2014; Sextos, 2014), self-evaluation test (Borondo et al., 2014), also called e-assessment (Francis & Shannon, 2013; Papathanassiou et al., 2013; Sextos, 2014; Sorensen, 2013), virtual lab (Borondo et al., 2014; Malkawi & Al-Araidah, 2013; Sextos, 2014) or remote laboratories (Kulich et al., 2013; Lowe, Dang, Daniel, Murray, & Lindsay, 2015) in order to simulate experiments, digital games (Fatahi & Khabbaz, 2015), etc. According to Le at al., as cited in Francis and Shannon (2013), “blended learning takes its place among online learning modes as an instructional technique that marries the benefits of social and collaborative interaction between students and staff together with the qualities of self-paced learning, reiteration and revision from the online components” (p.361). Although social components are generally maintained, fully online courses are also developed (Aikaterini, 2014; Choulier, 2015; Suhonen & Tiili, 2015).

Taking into consideration the example of the MSc degree at TU Delft in Aerospace Engineering, some courses can be followed online by the students. Students access a Learning Management Platform (LMS) in order to follow an approximately 10-week course. They can watch recorded class lectures, access learning resources and deliver online assignments like quiz.

ICT is a way to provide distance education in order to address lifelong learning and continuing education. TU Delfts offers a suite of specialized online classes (see online-learning.tudelft.nl). To attend the online course, the entry level is a BSc-degree in a relevant field of engineering or comparable. Each course can be made of up to 20 learners, and range from 7 to 17 weeks duration, for a price from 600€ to 1250€, with a workload of approximately 8-10 hours/week. The university’s website specifies that combining study with a regular job requires motivation and determination. If the learner successfully complete the online course he/she will be awarded with a TU Delft certificate. This certificate states that the learner registered as a non-degree-seeking student at TU Delft and successfully completed the course

(TUDelftOnline, 2016). Interestingly, the University of Technology Belfort Montbeliard, through the InnovENT-e IDEFI program, developed online courses for the provision of hybrid and full distance learning in initial and continuing education (Choulier, 2015). Finally, in the case of TU Delft, an open and introductory course in Aeronautical Engineering is made available on the edX platform. The MOOC, Massive Open Online Course, is a self-paced course representing 84 hours of self-learning (TUDelftMOOC, 2016).

On a more general stand, in France, the universities and "Grandes Ecoles" made their online material available to all. The search engine "sup-numerique.gouv.fr" is a single access point to the different repositories of digital resources in higher education. It gives access to the different UNTs (Universités Numériques Thematiques). The UNIT foundation (Université Numérique Ingénierie et Technologie) provides learning resources in technical and engineering fields. It gathers around 70 universities, "Grandes Ecoles" and companies. UNIT offers an open access to 2500 digital resources for their use by students and teachers. In addition, another UNT is Unisciel, an online scientific university gathering learning resources from over 40 universities and "Grandes Ecoles" which correspond to bachelor degrees. It offers resources in Physics, Mathematics, Chemistry, Computer Science, Biology, and Geology. Besides, the France Universite Numerique (FUN) portal is also accessible from "sup-numerique.gouv.fr". FUN offers MOOCs from many French universities and "Grandes Ecoles".

1.2.2. Blended Learning in Corporations

The description of current training practices in industrial corporations, especially for technical training, are seldom published.

In corporations, in addition to scalability and flexibility for cost reduction purpose (anytime, anyplace), technology application is seen as an opportunity to shorten the classroom session (Collis et al., 2005) through the use of tutorial content (Ubell, 2010). In the US corporations, technology-based methods account for 37.3% of formal hours available across all learning methods (ASTD, 2012). As of 2011, Western Europe is the second largest buying region of self-paced e-learning after North America with $6.1 billion reached in 2011 (Insight, 2012). In the European industry, blended learning is establishing itself as the benchmark training method with 76% of European barometer respondents (CrossKnowledge, 2011) and 47% of companies decided to expand its use in the short term.

1.2.3. Cost of Blended Learning

Hereafter, the cost of technology-enhanced learning is considered (see Table 4 for the cost structure of blended learning).

Table 4. Type of cost for blended learning. Adapted from 'Figure 3 : spending for blended corporate training', (Crepon, 2012). FC and VC mean "Fixed Cost" and "Variable Cost" respectively.

<table>
<tr><th></th><th>Initial cost</th><th>Class delivery</th></tr>
<tr><td rowspan="2">e-learning</td><td>Content design & development:
multimedia material (FC)</td><td rowspan="2">Support, scaffolding (VC)
LMS maintenance (FC+VC)</td></tr>
<tr><td>Infrastructure:
hardware, networks, LMS (FC+VC)</td></tr>
<tr><td rowspan="4">Traditional class</td><td>Traditional class material:
hardcopies, print (VC)</td><td rowspan="2">In corporation:
- tuition fees, travels (VC)
- production loss/labor cost (VC)</td></tr>
<tr><td rowspan="3">Class preparation: time (FC+VC)</td></tr>
<tr><td>Teacher:
- salary (VC)</td></tr>
<tr><td>Running costs: facilities, administration (FC+VC)</td></tr>
</table>

Information and Communications Technology (ICT) development and, in particular, tailor-made e-learning contents are known to be expensive due to the utilization of technology, to further project management activities and to extra training activities for design strategies, tools, processes, and standards (Gagne et al., 2005).

In the late 90s, the e-learning sector saw the emergence of the Learning Objects (LO). A learning object is an "independent and self-standing unit of learning content that is predisposed to reuse in multiple instructional contexts" (Polsani, 2003). The main advantages of using LO were essentially technical and economical while at the pedagogical level questions remain (Jenni, 2009). Among the main limitations, LO should be internally contextualized to a certain degree thus preventing from being combined with other LO (Wiley, 2002), the socio-cultural attitudes towards collaboration can prevent sharing (Littlejohn, as quoted in Elliott and Sweeney (2008)) and the modification of LO can necessitate the support of a professional multimedia team (Elliott & Sweeney, 2008). Nowadays, Open Educational Resources (OER) are equivalent to LO but are open to all, proving especially useful in order to address the massification of education worldwide. As cited in Tovar and Piedra (2014), the Organization for Economic Co-operation and Development (OECD) defines OER as "digitized materials offered freely and openly for educators, students, and self-learners to use and reuse for teaching, learning and research" (OECD, 2007).

More than ever, the impact of the economic crisis calls for efficient and cost-effective learning solutions. Between 2010 and 2011, budgets for tertiary and adult education in Europe have been reduced in nearly half of the twenty eight countries (Eurydice, 2013). According to European experts in education, the decrease of public funding pushes forward public-private partnerships (Learnovation, 2008). For university, one way is to partner with private and business organizations (Hughes, 2001). UBC for the design of digital learning resources would be an opportunity to share the initial investment, known to be high in technology related development, between few local partners. In contrast to the LO and OER paradigm, which emphasizes economic and scalable aspects to address the massification and globalization of education, public-private collaboration is deemed to lower the development cost of digital resources in addition to addressing comprehensive and local educational needs.

1.3. Existing Models of University-Business Collaboration in the Field of Engineering Education

UBC in EE is defined herein as a partnership between one or many HEIs and one or many business organizations, with the purpose to deliver formal learning solutions among the respective communities of learners. As recalled by Heywood (2005), in Great Britain, the Finniston Committee stated that "the academic years should seek best to develop in students the analytical and scientific foundations on which they will build their practical skills". Industry was expected to play a key part in the first years of work. Both HEI and companies thus play an active role in educating young and professional engineers respectively. However, do collaborative frameworks exist between academia and industry in the field of EE?

According to the Hippo Study (Davey, Baaken, Galan Muros, & Meerman, 2011), two thirds of HEIs undertake UBC activities, and technology and engineering have the highest level of UBC. There are eight main different ways in which HEIs and business cooperate, ordered from the most usual to the less common: collaboration in Research and Development (R&D), mobility of students, commercialization of R&D results, lifelong learning, curriculum development and delivery, entrepreneurship, governance, mobility of academics. It has been found that the main barriers to productive UBC are the funding and bureaucracy (Davey et al., 2011), the inflexible approach to IP (Board, 2012), the use of poor metrics such as the number of papers published or patent applications filed instead of quality (Board, 2012), the lack of academics with deep understanding of industry and business experience (Board, 2012), and, in addition, the difficulty to devise mechanisms in order to share accountability (Board, 2012).

Table 5. Examples of partnerships between universities and companies. Built from partial information (Aggarwal & Vernaza, 2012; Board, 2012; Davey et al., 2011; Fink et al., 2007; Hughes, 2001; Laux & Razdan, 2009). U is used for 'university' and B for the 'business' context.

Activity of collaboration	**Kind of partnership**	**Organization**	**Participants**	**Benefits**
Research activity[1]	Strategic[2] Transactional	Consortia, joint program, graduate program.	Undergraduate, graduate students, graduate thesis, faculty consultancy, managers, researchers.	Students (U): educational value, scientific research method, occupational guidance, Faculty (U): external funding, Intellectual Property (IP), tacit knowledge production, knowledge body expansion in one discipline, new teaching content, HR (B): talent search, Specialists (B): allow new technical capabilities, Managers (B): product/service improvement, All: solutions for social and global challenges.
Design projects	Transactional Operational	Industry relevant challenges	Undergraduate, graduate students, faculty, professionals.	Student (U): educational value, work experience, occupational guidance, HR (B): talent search, Managers (B): inexpensive student labor.
Student mobility	Transactional	Internship and cooperative education ('co-op' programs, apprenticeships, trainee programs).	Undergraduate, graduate students, managers.	Students (U): work experience, financial support, educational value, occupational guidance, Managers (B): inexpensive student labor, social contribution.
Teaching collaboration	Transactional Operational	Accredited university degree-granting programs, special courses, industrial affiliates programs, multidisciplinary degree programs, Facilitated Work Based Learning (FWBL)[3].	Faculty, industry specialists.	Faculty (U): external funding, educational value, new topics introduction, modernize teaching and learning, Employees (B): career and personal development.
Discrete activities	Transactional	Visiting speakers, industrial tours	Teachers, professionals.	UB relationship, educational & motivational value, new topics introduction, occupational guidance.

[1] Only 40% of the projects with major research outcomes were exploited in ways that led to major impact, defined as an observable and generally agreed-upon positive effect on the company's competitiveness or productivity (Pertuzé, 2010).

[2] Audi built the Ingolstadt Research Institute in collaboration with the Technical University of Munich. This UBC went beyond transactional research projects, focusing mainly on technology and innovation for direct application on Audi's cars and on the pool of future talents (Board, 2012).

[3] The "Lonely Wolf" case: facilitated work based learning (Fink, Rokklaer, Norgaard, & Lemke, 2005).

Table 5 organizes the main UBC frameworks in five different categories: research activities, design projects, student mobility, teaching collaboration and discrete activities. According to Chandrasekaran, Littlefair, and Stojcevski (2015), research and design projects are a way to involve students in authentic learning in order to develop their practical knowledge. Student mobility includes internship and cooperative education programs; teaching collaboration is mainly composed of degree-granting programs delivered by universities; while discrete activities cover all the punctual activities such as visiting speakers to universities or industrial tours. It is understood that most university-business partnerships are transactional activities in which services, not always centered on educational values, are either provided by universities or companies in exchange of direct or indirect financial retribution. Indeed, in HEI, it has been found that among the main interests in research collaboration with companies are the need for external funding (Board, 2012; Hughes, 2001) and the interest for Intellectual Property (IP) (Hughes, 2001).

Considering collaboration in formal education, companies outsource part of their training to external providers. The situation is much contrasted in Europe between countries and their different legislations and financing programs. Training might be outsourced to private centers, to industry branch associations or to universities for accredited degree granting programs. As way of example, tuition reimbursement accounted for 14% of the total direct expenditure of US organizations in 2011 (ASTD, 2012).

Are Universities and Corporations Partnering Up in Engineering Education?

Several models of UBC already exist in EE. Firstly, from academia to industry, there are degree granting programs and online distance teaching university programs. For continuing education, universities are in competition with private training centers and industry branch associations. Secondly, from business to university, companies generally provide business solutions for learning. It is the case of software providers for collaborative solutions (social networks and tools, web conferencing), for technical data management (content management systems, database providers, laboratory data management systems), and for design activities in engineering (computer-aided design software, computational software, modelling software). However, this model remains transactional and does not involve educators from both sides to collaborate on core subject-matter knowledge. Thirdly, there are third party and highly specialized firms which are leaders in their scientific and technical segment. They offer consulting and training services to both HEI and companies.

The clearest example of UBC for LR creation, although not a UBC where the industry plays an active role in the ID, comes from the Lonely Wolf project and the general concept of Work Based Learning (WBL) (Fink et al., 2005; Norgaard et al., 2015). The project dealt with the training of engineers in dispersed small- and medium-sized companies in Denmark. On the one hand, it has been noticed that the engineering practices are more and more specialized, making it difficult to source convenient courses from universities. On the other hand, small organizations cannot afford courses-on-demand, where course content is customized to the needs of engineers. Besides, job rotation is difficult to organize if someone wishes to go to external training sites. In addition, the scale effect, which usually makes e-leaning cost effective in global organizations, is not achievable with few employees to train on specific subjects. The solution has been the original implementation of what has been called a Facilitated Working Based Learning (FWBL) where university researchers are involved in tailor-made instruction to employees at their workplace. It included a mix of standard classes from university programs, reading and problem solving, academic researcher review and meetings.

From the literature, no publication has been found related to the description of instructional methods or principles that would apply to the specific design of learning resources for their use among few academic and corporate organizations in EE. Of course, it is not expected that teachers and instructors have not collaborated or do not collaborate for particular course designs. However, no research work, projects, or methods with the aim of explicating the assumptions and the decisions for the collaborative design of LR between university and business have been found. The development of a University-Business knowledge on instructional design is deemed necessary to guide instructors from both contexts in their design of enriched teaching content by bringing academic and business perspectives together. As a consequence, and in contrast with transactional activities, the direct collaboration of faculty members with corporate instructors would allow knowledge circulation between research and industry, between initial and continuing education and develop academics with a deeper understanding of industry and business. On the other hand, students would benefit from advanced scientific and technical knowledge connected to real industry challenges.

2. EMPIRICAL WORK

The development of a University-Business knowledge on instructional design is deemed necessary to guide instructors from both contexts in their design of enriched teaching content by bringing academic and business perspectives together. More generally, new common practices would create bridges between what Boisclair called in Brémaud and Boisclair (2012) "the places of research production and theoretical knowledge, and the world of emergence of practical and action knowledge", namely academia and industry. In absence of detailed studies on the design of common instruction between university and business, this research has been conducted in order to understand the assumptions and the decisions for the collaborative design of LR between university and business.

2.1. The Research

The research project is concerned "with evidence-based principles for how to help people learn" (Mayer, 2009) in EE. It is an applied research in order to derive principles of instructional design (ID) in the science of instruction. In particular, it aims to study the ID methods for the design of digital learning resources that would support blended learning in both academia and industry. As will be explained later, the research does not intend to validate hypotheses under controlled conditions, nor to validate cause-and-effect relationships, nor to predict phenomenon. However, the aim is to induce instructional principles directly from grounded observation made from innovative practices in real world environments.

As shown in Figure 15, blended learning is considered where the learner has access to the two following learning activities:

- Computer Based Training for asynchronous self-learning,
- Traditional lecture with the guidance of a teacher (teaching staff or instructor).

In the context of the study, this research is restricted to digital learning resources. Following Gagné's (2005) definition, (a) the delivery methods under scrutiny are computers and mobile terminals; (b) the instructional strategy involves both computer based and teacher led activities to facilitate deep understanding (blended learning approach). According to the multimedia learning classification (Mayer, 2009), (a) the delivery media is a computer screen, speakers and a mouse or touch pad, (b) the presentation mode is through words, pictures and interaction; and finally (c) the sensory modality is auditory, visual, and touch.

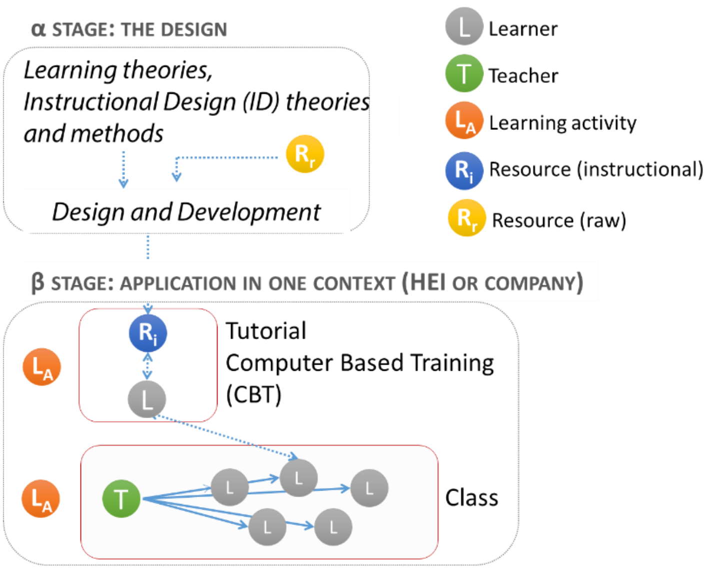


Figure 15. The research study: learning resources design for blended learning at HEI and company

The study covers 12 blended courses, seven at HEI, and five professional trainings, including one training held in a research institute. In total, the whole study represents 182 learners, from which 151 are students and 31 are employees. Twelve practitioners participated to the research, representing 150 years of professional experience and 73 years of teaching.

The research has been conducted on small and purposive samples. They are teachers and instructors, from academia and industry, who accepted the invitation to participate to the research study. The participation of all the contributors to this research and their willingness to continue using the module is a signal of the interest in designing purposive resources that would enable new practices in teaching.

2.1.1. Problem Statement

Although Higher Education Institutions (HEIs) and companies have different objectives, organizations and cultures, they hold similar learning and development necessities to create engineering minds. They both aim to develop people's problem-solving capacities from authentic material, while keeping learners' motivation high and facilitating the career guidance and development of engineers (Billet, 2011). The collaborative design of instructional material which could be used for blended learning in both academia and industry is deemed able to organize the exchanges between faculty and professionals and to set instructional goals oriented towards the entire population of learners in initial and continuing Engineering Education (EE).

In this context, the research question became: how can we design learning resources, specifically multimedia based ones, to guarantee their effective use in two different and identified contexts, namely academia and industry? In particular, such material and the associated design practice would help to address the following needs:

1. Need for cost effective solutions during economic downturn. UBC will contribute to share the investments for e-learning solutions development.
2. Need to make knowledge circulation happen between academia, research and industry for innovation and economic growth. UBC in education and training will enable research knowledge dissemination, vocational learning to fill the skill gaps in STEM and lower time-to-competency.
3. Need to develop professional skills for successful UBC management. UBC will foster communities of practice (Wenger, McDermott, & Snyder, 2002) in EE, whose actors will develop the special abilities to manage cross-organizational activities in technical knowledge diffusion.

Hopefully, the research outputs would help instructional designers to conceive, develop, reuse and even ease the financing of purposeful learning resources between HEI and companies, and/or between the public and the private sector. As a consequence, the direct collaboration of faculty members with corporate instructors would allow knowledge circulation between research and industry, between initial and continuing education, and resulting in students benefitting from advanced scientific and technical knowledge connected to real industry challenges. It would also allow the development of a collaborative culture and a cross cultural understanding as the contributors from universities and business would learn to work together.

2.1.2. Objectives

The research project aims to articulate a University-Business model for Blended Learning in Engineering Education. The idea is to use grounded observations and their theoretical implications to increase the knowledge on the influence of the academic and corporate contexts on the design of instruction for blended learning.

In particular, interest is based on the factors influencing the design, the application and the usage of a common LR between academia and industry. The research aims to address the following questions:

1. Is the same learning resource used differently within academia and industry for blended learning?

2. What factors influence the application of a common learning resource within academia and industry?

3. What are the main factors to be considered for the design and application of such learning resource?

2.2. The Research Methodology

The specificity of the research project comes from the fact that it was improbable to find an existing project matching the conditions that would allow investigating a subject in the particular context of engineering education. Previous research work resulted too global and abstract to be useful in the particular UBC context. Indeed, a new and innovative teaching practice had to be investigated, with no prior example in mind. Consequently, innovative educational practices were set which were studied at the same time. As a consequence, the research methodology had to enable qualitative, exploratory and descriptive research in a complex and changing environment as particular situations or experiences were tried to be understood rather than validating them. Besides, the research methodology would allow reporting with fidelity the multiple perspectives and the dynamics between the key decision makers in the educational system.

2.2.1. The Design-Based Research Methodology

Design based research (DBR), firstly called "design experiments" by Brown (1992) and Collins (1992), then "development research" (Van den Akker, 1999) or "formative experiment" (Newman, 1992), is a genre of inquiry (McKenney & Reeves, 2012) especially useful to design and study an innovative solution to educational problems at the same time (Johri & Olds, 2011; McKenney & Reeves, 2012) (see Appendix 1). DBR methodology is flexible, and aims to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners, in real-world settings, and yields contextually-sensitive design principles and theories that can inform the work of others (Cohen et al., 2011; Newman, 1992; Wang & Hannafin, 2005) (Figure 16). It particularly fits with the research objectives to account for decisions related to the design of LR which are sensitive to the context of academia and industry. DBR advances design, research and practice concurrently. A research methodology describes why and how particular methods are selected to reach the desired outcomes (Case & Light, 2011). DBR involves mixed research methods, both quantitative and qualitative, to gather and analyze data from real environments with a multitude of context-specific and context-dependent variables. In addition, DRM usually involves purposive and non-probability sampling.

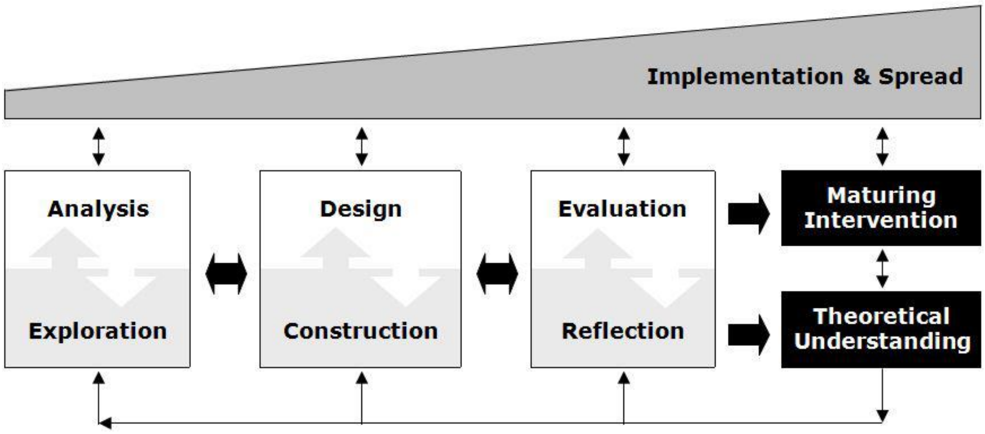


Figure 16. Generic model for conducting design research in education (McKenney & Reeves, 2012).

Some of the main characteristics of the design-based methodology are summarized hereafter:

- the "interventionist" dimension of DBR (McKenney & Reeves, 2012): the researcher role and the designer role are held by the same person. The research and design activities are retroactively analyzed by the same person but from different standpoints. As a researcher, the main goal is to guarantee the scientific value of the study, the rigor of the research and link theory with practice in education. One major task in DBR is to check results' confirmability, that is to say "the assurance that researcher findings are rooted in contexts and persons apart from the researcher, and that they did not merely arise in the researcher's imagination" (Case & Light, 2011). As a designer, the considerations are rather technical. Designers neither adopt their clients' values nor impose their own. They rather act as facilitators and they adapt to their clients' perspectives, beliefs, and strategies while aligning and extending the design processes (Wang & Hannafin, 2005).
- the "collaborative dimension" of DBR (McKenney & Reeves, 2012). The researcher collaborates with the practitioners.
- DBR is a genre of inquiry where reference theories are necessary to inform about the research decisions, to build and use relevant research tools. According to Case and Light (2011), theoretical perspective is "the philosophical stance informing the

methodology and thus providing a context for the process and grounding its logic and criteria". Theories in learning and educational sciences are used to frame the research, its methodology and also the logic and criteria of the design itself (Newman, 1992; Wang & Hannafin, 2005).

- the "flexibility" of DBR (McKenney & Reeves, 2012). At any time of the research, the researcher can find and create the conditions to achieve his research goals. In real world settings, this implies to constantly adjust to different dynamic variables as well as external influences. This unique flexibility for a research methodology gives DBR the possibility to generate instructional design methods that are sensitive to the context.
- DBR is a "multilevel" inquiry (McKenney & Reeves, 2012). In contrast with laboratory experiments where controlled variables are measured, real-world settings expose us to factors that are not directly related to the study.

It is a relevant research methodology to generate induced theories and principles from observation of innovative practices in real world environments. Whereas DBR, implemented in real world environments, has a high ecological and external validity (McKenney & Reeves, 2012), it should be reminded that it deals with purposive and small scale sampling. Therefore, the range of contexts for the application of the research is limited; in case herein, it concerns the design of LR for blended learning in engineering education, and for HEI and companies. This considerably limits the size of the population most likely to use the object of design (the tutorial module). For all these reasons, the use of statistical generalizability for the purpose of this research has not been considered (Case & Light, 2011).

2.2.2. Application of the Design-Based Research Methodology

In the context of the research project, DBR has emerged as the most appropriate research methodology in order to set innovative educational practices and to study them at the same time, and in real world settings. The researcher set innovative practices that would not be implemented in current educational and organizational settings. Indeed, there are few incentives or opportunities given to teachers and instructors to design common LR across universities and companies. DBR implies working in highly uncertain environments because many external variables are at stake. These external factors represent the natural embedding environments for which the object of design has to be engineered.

Using DBR, an e-learning module has been engineered in Geostatistics, in real world settings and in collaboration with instructors from industry and teachers from universities. The module, a self-paced tutorial, is aimed to be completed by learners before traditional lectures at university and before training in the company (Figure 15). The module has been refined iteratively along the design process. The research is conducted on interventions, that is to say, directly on the methods used to design the educational resource (McKenney & Reeves, 2012) (Figure 17).

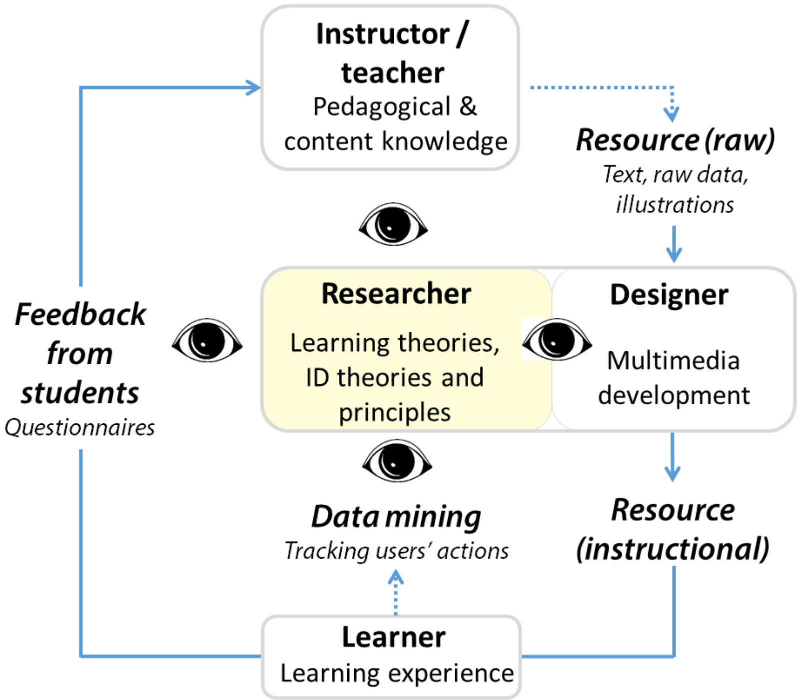


Figure 17. The research is conducted on interventions

Figure 17 shows the researcher as a researcher and a designer at the same time. As a researcher, he defines the investigation methods in authentic environments to reach the research outcomes. In the case herein, the decision was taken to follow the DBR cycles described in Figure 16. First, a pilot phase was designed. The pilot phase, also called "prototyping" in Table 6, allowed to design a prototype in order to evaluate:

- The design of the module for further improvement before the meso-cycle "analysis and reflection",
- The research methods: validation of the questionnaires and of the tracking of the user experience.

During the prototype phase the researcher got familiarized with the people, the resources, and the organizational constraints, and tried to lessen his obstructiveness in the learning environment (Wang & Hannafin, 2005). As a designer, the researcher was also in charge of developing the LR along with addressing the specific issues that rose during the design and development phase. Retrospective analysis was made with the practitioners in order to identify the strengths and weaknesses of the original design and he designed refinement to reach intermediate and ultimate design goals. He also tried to minimize the bias of being the single designer, and of external influences.

Table 6. Main phases of the DBR. Adapted from the generic model for design research described by McKenney and Reeves (2012)

Analysis and exploration	**Design and construction**	**Evaluation and reflection**	**Design and construction**	**Evaluation and reflection**	**Analysis and exploration**
Micro cycle	Micro cycle	Micro cycle	Micro cycle	Micro cycle	Micro cycle
	Meso cycle “**prototyping**”			Meso cycle “analysis and reflection”	
Research question Literature review	First design and improvement Test of the research methods (data collection)			Empirical testing of the refined design with validated methods	
	72 students / 7 employees, 5 courses			79 students / 24 employees, 7 courses	

The main characteristics of the DBR methodology applied to the research are:

- the “interventionist” dimension of DBR (McKenney & Reeves, 2012): after the implementation of the prototype design, the decisions, the opinion of instructors, teachers and students have been analyzed from a pedagogical perspective, feeding the research and leading to design improvements.
- the “collaborative” dimension of DBR (McKenney & Reeves, 2012): along the study, the researcher developed and maintained contact with instructors in companies and with teachers in engineering schools. The exchanges included meetings, phone and web conferencing. For the pilot design, the instructors were interviewed first. The discussions were mainly focused on the structure of the course, on the teaching matter itself, on the main concepts and principles of the discipline, on the representations to use, and on the design of self-assessing tools through short practices by means of interactive exercises and quizz. Later, exchanges with teachers and instructors consisted in adapting the design to the course structure when necessary and making small adjustments.
- the “theoretical” orientation of DBR (McKenney & Reeves, 2012): the exchanges between the researcher, the instructors and the teachers were not random. A theoretical framework was necessary to inform the logic of the study. In the case herein, the research project follows an approach consistent with its naturalistic and post-positivist epistemological

positioning. The subjective dimension of the design process of LR and its relation to real-life systems of thought, people and action were considered. The approach is considered to be in line with socio-constructivist theories and the principles of Situated Cognition:

  - Socio-constructivist approaches assume that all knowledge is constructed from social interactions and from the learner's previous knowledge (Zierer & Seel, 2012), might it be true or false (Astolfi & Develay, 2005).
  - According to Situated Cognition, every learning experience is embedded within a natural, social and material context. Therefore, the role of tools is important to be well understood, especially for learning activities (Johri & Olds, 2011). In the context of the study, there is a special interest in understanding the "complex transactions between embodied minds and the embedding world" (Robbins & Aydede, 2009). Of particular consideration is how the use of technology extends learners' epistemic reach while allowing off-loading cognitive work onto the environment (Robbins & Aydede, 2009).

- the "flexibility" of DBR (McKenney & Reeves, 2012): natural and disruptive changes in the organization of the study can turn out to be opportunities to generate context sensitive principles and to extend the research reach. An example of unpredicted change has been the arrival of a new teacher at one of the engineering schools, making it possible to reconsider the course structure in Geostatistics and to integrate the e-learning module as a course activity in its own right.
- DBR is a "multilevel" inquiry (McKenney & Reeves, 2012): the general orientation of the research in education can easily be in tension with administrative, political, financial or technical considerations. The risk to deviate from the desired research trajectory is proportional to the number of systems in interaction (institutions, people, etc.). As a result, the researcher had to facilitate the adoption of the object of design to make the study happen. A high level of effort can be put in administrative or technical tasks while it will not necessarily be reflected in the research results. As far as can be judged, these hurdles partially explain why DBR is demanding in order to study real world phenomenon and even more across the public and private sectors. Anyhow, the main value of DBR is precisely to account for practices and determine factors which will promote or prevent the success of the design in real-life contexts.

2.3. The Population and the Samples of Teachers and Learners

Two different universities, three companies and one research institute participated in the research. They used the e-tutorial for their courses and training, the teachers and the learners filled in questionnaires, some instructors were interviewed while others made a detailed review of the module.

The following sections describe in detail the different institutions and their role in the study.

2.3.1. Initial Education: the Universities

IFP School is an applied engineering school in the disciplines related to energy and transportation. According to the IFP school website (www.ifp-school.com):

> "the programs aim to provide students with all the skills and knowledge necessary for their chosen profession so that they are immediately operational upon graduation. The school has 40 permanent professors and delivers programs at master's level, including 7 English-language programs and has 500 graduates per year: 350 Engineering / Master's students, 100 Research Master's, 50 executive programs, with 50% of graduates being international students. One particularity of the school is its orientation to industry, with 80% of students receiving industry-backed financing. The school's offer includes 10 industry-oriented graduate programs, organized into four major fields of energy and transportation: exploration and production, energy sector processes, powertrains and products, economics-management".

The research has been conducted within three courses of Geostatistics delivered by two different professors from the exploration and production cycle: Master in Reservoir Geoscience and Engineering (RGE) and Master in Petroleum GeoSciences (PGS).

During the pilot phase of the study, the tutorial was used during the introductory course in Geostatistics. Three groups of students followed the blended learning course: students from PGS with a specialty in Geology, students from PGS with a specialty in Geophysics, and students from RGE who chose elective courses in advanced Reservoir Characterization

Methods (RCM). In addition, the module has been made available on a stand-alone basis for all the RGE students. During the prototyping phase, class in Geostatistics was delivered by an external instructor, a consultant from the company Geovariances. The university teacher was in charge of the teaching unit supervision and gave a two week introductory lecture in Reservoir Characterization in February 2014. Later on, the teacher took charge of the teaching in Geostatistics.

In 2014, the enhanced version of the module was used by all the RGE students during a practical workshop, and also by all the students from PGS, after traditional class and before practical work.

Below is a summary table of the courses for which the e-learning module has been used:

Students	**Instructional strategy**	**Date**
PGS-GOL	Blended	10-11/06/2013
PGS-GOP	Blended	10-11/06/2013
RGE	Virtual, on demand	
RGE-RCM	Blended, during practical work	12/06/2013
RGE	Blended, during practical work	4-5-6/03/2014
PGS	After traditional class, before practical work	16/06/2014

The instructor answered the questionnaire and was interviewed.

According to the information collected from the school website (www.minasyenergia.upm.es/en/), the Polytechnics University of Madrid (UPM) was founded in 1971 through the integration of the Higher Technical Schools which up until then made up the Higher Technical Institutes. The University Schools joined the following year. The Engineering School of Mining is part of UPM.

The year 2014-2015 was the first year of the master in Geology Engineering. Geostatistics is delivered as an elective module which is taught over one month. During this elective class students were asked to complete the e-learning module and quizz.

Learners	**Instructional strategy**	**Date**
Master in geology and engineering	Blended	From 09/02/2015 to 13/03/2015

The instructor of the course answered the questionnaire.

2.3.2. Continuing Education: the Companies and the Research Institute

Repsol is an integrated oil and gas company and operates throughout the entire energy value chain including exploration, production, refining, marketing and new energy research and development. Repsol's corporate headquarters are located in Madrid, Spain. According to the company's website (www.repsol.com), Repsol operates in over 30 countries with 25,000 employees worldwide.

The tutorial module was first designed for its use in one of the first blended courses in Geosciences at the Repsol's Training Center in Móstoles, Madrid. The design work was conducted with the instructor and further refined for the module distribution throughout the company's LMS. E-learning was implemented with the aim of improving time management and shortening class duration and increasing the value of social exchanges during class. For that purpose, the module explains the main concepts and the relations between principles, all prior to class in order to increase awareness, curiosity, and enable preliminary practice.

The learners' profiles are diverse and include mathematicians, geologists, geophysicists, petrophysicists and reservoir engineers. The trained people came from the Technological Center of Repsol and from other Business Units worldwide. The course was an introductory course in Geostatistics and registration was open to all Repsol employees.

Below is a summary of the different training sessions:

Learners	**Instructional strategy**	**Date**
Professionals from different disciplines	Blended	3-4-5/06/2013
Professionals from different disciplines	Blended	3-4-5/02/2014

The instructor answered the questionnaire and was interviewed.

Geovariances is a French independent software vendor specialized in geostatistical resource evaluation which was set up in 1986. The company employs 40 people, including 12 consultants and 12 software developers. The company also provides training and consulting services in Geostatistics. It invests continuously in research and development through research consortia or partnerships with research leaders in their respective industries (e.g. Mines ParisTech for the development of Isatis, CEA for the development of Kartotrak). The company offers its services to different sectors: mining, oil & gas, environment and any field where Geostatistics applies, including civil engineering, fisheries, oceanology, agriculture, forestry, epidemiology.... With regard to training in Geostatistics, the company delivers catalogue listed and tailored sessions, public and intra-company sessions, for beginners and skilled geostatisticians.

Below is the information on the training delivered by Geovariances:

Learners	**Instructional strategy**	**Date**
Professionals from different disciplines within one oil & gas client company	Blended	19-20/11/2014

The instructor of the training and three other trainers from the company answered the questionnaire.

According to the information collected from the company's website (www.beicip.com), Beicip Franlab is an "independent petroleum consultancy firm and geoscience software editor. For over 45 years, the company has been providing consultancy and software solutions in exploration, reservoir and field development, production optimization, process optimization, [and] midstream-downstream studies".

The company offers consulting services, software solutions, technical assistance and advisory services. The permanent staff is made up of over 250 experts. They cover a wide range of expertise (in geoscience, in oil and gas production, in process optimization) and in the economic-contractual domains.

The e-tutorial has been used in preparation of a training course on a software called Cobraflow.

Learners	**Instructional strategy**	**Date**
Professionals from BEICIP	Blended	14-15/04/2014

The instructor of the course answered the questionnaire.

IGME is the Spanish Institute in Geology and Mining. According to the institutional website (www.igme.es), the main mission of IGME is to provide the State Administration, the Autonomous Regions' Administrations and the general society with precise knowledge and information regarding Earth Sciences and related technologies for any development throughout Spanish territory. IGME was created by Royal Decree of 12th July, 1849, with the original denomination of “Commission for the Geological Chart of Madrid and the Kingdom of Spain”. Today IGME is a self-governing Public Research Institution attached to the Ministry of Economy and Competitiveness.

Learners	Instructional strategy	Date
Professionals from IGME, CIEMAT and INTA	Blended	27-28-29-30/10/2014

The instructor of the course answered the questionnaire.

In addition, three professionals reviewed the module and filled in the questionnaires.

The Head of the Imaging and Training Division in geosciences and the Training Manager in Geostatistics, both from TOTAL, reviewed the module in detail and filled the questionnaire. According to the company’s website (www.total.com), TOTAL is the world’s fourth-largest oil and gas company and the second-largest solar energy operator with SunPower. With operations in over 130 countries, the company has over 100,000 employees.

The Head of the Geology Department at IFPEN also participated to the study. The questionnaire was completed and an interviewed was conducted. IFP Energies nouvelles (IFPEN) is a public-sector research and training center. It has international scope, covering the fields of energy, transport and the environment. According to the institute’s website (www.ifpenergiesnouvelles.com) IFPEN represents 1,661 employees, including 1,139 researchers.

2.3.3. Multimedia Development

API-LEARNING is an e-learning company specialized in engineering and applied sciences. Rémy Crepon, the founding director of the company, conducted this research in order to increase knowledge in the field of learning resources design for initial and continuing education in scientific disciplines.

Table 7 shows the samples available for the study. Phase I corresponds to the "prototyping" cycle of Table 6. The prototype was tested on 79 students and 7 employees. After this first successful application, small design adjustments were made and the data collection system was enhanced. Indeed, the tracking system to collect users' interactions was improved and questionnaires were revised with the help of professionals from the e-learning field, from the EE field and from the research field in EE.

The Phase II corresponds to the second meso-cycle called "analysis and reflection" in Table 6. It is the evaluation phase of the study corresponding to the empirical testing carried out with the advanced design. It covers seven blended courses, three at HEI and four professional trainings, including one training held in a research institute. The study represents 103 learners, from which 79 are students and 24 are employees, distinct from the prototyping phase.

Table 7. Groups and data collected for the study (sampling)

Phase	**Course Code**	**Institution**	**Number of learners**	**Number of users**		**Feedback from learners**		Feedback from instructors
				N	**%**	**N**	**%**	
I	1	Company A	7	6	86	7	100	1
	2	University A	22	14	64	6	15	1
	3	University A	19	13	68			
	4*	University A	18	3	17	0	0	
	5	University A	13	3	23	1	8	
Total			79	39	49%	14	18%	2
II	6	Company A	7	7	100	7	100	1
	7	University A	30	30	100	27	90	1
	8	University A	42	29	69	24	57	
	9	Company B	6	4	67	4	67	1
	10	Institute A	6	5	83	6	100	1
	11	Company C	5	5	100	5	100	4
	12	University B	7	7	100	5	71	1
Total			103	87	84%	78	76%	9

*optional: available online for consultation, was not part of a blended course

2.4. Learning Material Design

In order to conduct the research, an e-learning tutorial was designed in Geostatistics. In the coming sections, the module is described, also called the object of design in reference to the DBR methodology.

2.4.1. The Object of Design

The e-learning module gives an introduction to the main principles of Geostatistics and their application to geological reservoir modeling. Following Gagné's categories (Gagne et al., 2005), the instructional delivery strategy is of a tutorial nature to allow self-pace learning in order to help learners prepare for class, the instructional media are diverse (audio, words, 2D & 3D graphics and animated illustrations), and instruction is delivered using a Computer Based Training method (online learning).

The digital learning resource was originally built to address the needs of engineering education and training in the Oil & Gas industry. The learners receive an introduction to the most important concepts, all in an interactive and visual manner. The module is composed of four chapters, namely "spatial analysis", "spatial correlation", "spatial estimations" and "spatial simulations". The entire module has been designed to last around 40 minutes, although it has been observed that committed learners could spend over 90 minutes, especially on solving the exercises.

The module can be modified to adapt the course structure within the "client's" organization. As way of example, in the context of one corporate training, the module was split into two sub-modules (or tracks). "Track 1" covered the first two chapters "spatial analysis" and "spatial correlation". "Track 2" covered the following chapters, "spatial estimations" and "spatial simulations" (Figure 18). Each track had to be completed for a given day of the training session.

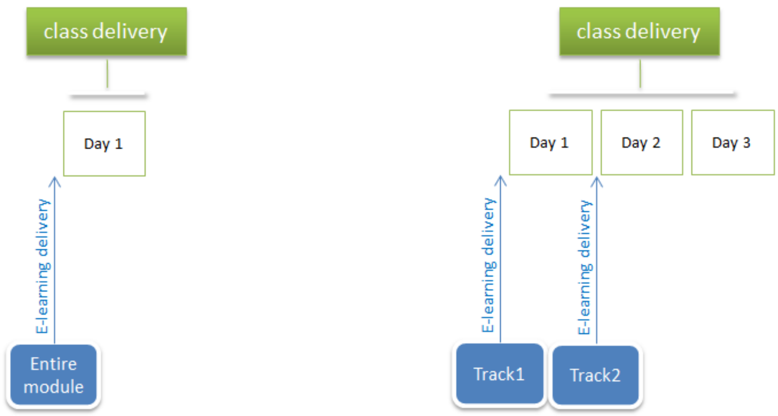


Figure 18. Example of two different delivery timing

When accessing the module, the learner is given the composition of the module (see Table 11). An illustration represents the general organization of the course as it is usually taught.

It has been graphically designed so that the relationship between the course topics is made explicit from the beginning trying to avoid later confusions between new concepts. That is the reason why we call this first view a "graphic organizer" in the sense that it "visually depicts key facts, concepts and important relationships" (Marchand-Martella, Miller, & MacQueen, 1998) (cf. "Signaling" principle from Mayer (2009)).

All along the module, the main information is displayed on the "main screen" (Figure 19).

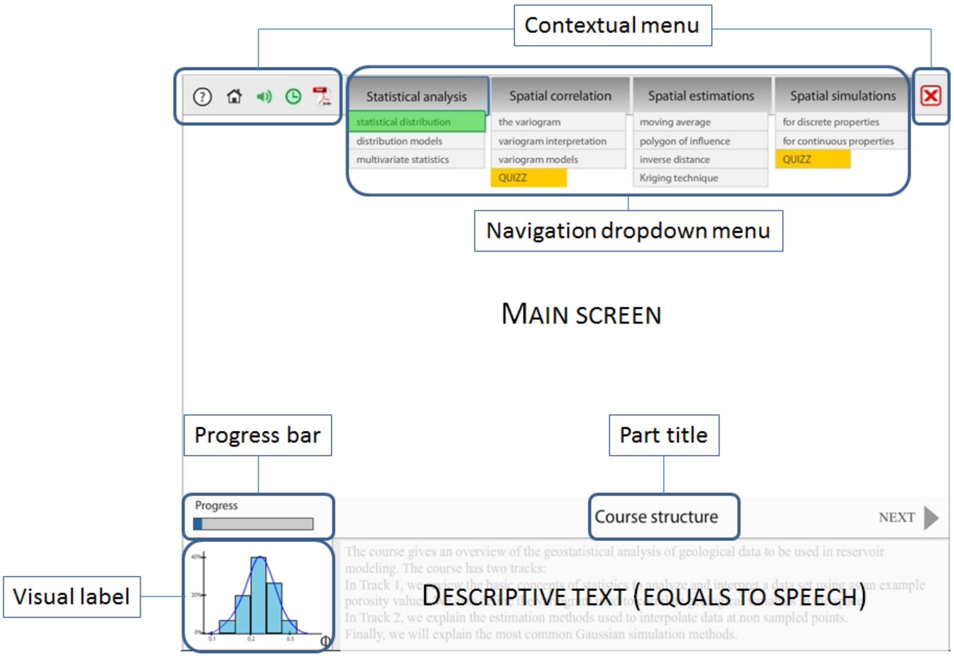


Figure 19. Composition and organization of the screen layout

The content is very illustrative, with narrated illustrations and animations (cf. "multimedia" principle from Mayer (2009)), short sentences and very little text (cf. "redundancy" principle from Mayer (2009)). Each "scene" tried to get as close as possible to scientific and mental representations (cf. "coherence" and "spatial contiguity" principle from Mayer (2009)). It generally involves 2D & 3D illustrations and interactive animations. In addition, a natural voice-over (cf. "modality" and "voice" principles from Mayer (2009)) explains the concepts synchronously (cf. "temporal contiguity" principle from Mayer (2009)) with the animations on screen. The entire speech is written in the "descriptive text" area, but no narration is provided for exercises (cf. "coherence" principle from Mayer (2009)). An improvement would be to display the printed text after the spoken text (cf. "modality" principle from Mayer (2009)). At any time of the module, the learner knows exactly at which point he/she stands in the learning process by means of three features:

- a "progress bar";

- a "visual label" symbolizing the main concept explained in the current section of the module;
- a "navigation dropdown menu", where the sections that have already been covered appear in green, and the current section appears with a blue borderline.

The navigation dropdown menu and the visual label comply with the "signaling" and "segmenting" principle (Mayer, 2009) which has been improved with the addition of "play" and "pause" buttons in latter versions. The "personalization" principle (Mayer, 2009) has not been tested in the study. To finish, the user also has access to a contextual menu. It allows switching the sound on and off, going back to the graphic organizer, deactivating the animations for a fast review and also to open a handout of the module in order to be printed.

The first chapter and its recall on statistics is coherent with Mayer (2009) "pre training" principle. The module includes five Excel™-based exercises, referring to one single dataset of 30 points with two interactive exercises and auto-corrected exercises embedded in the module. In addition, there are two scored quizz, one at the end of chapter 2 and one at the end of chapter 4. The module is SCORM™ compliant in both the "1.2" and "2004" version. For its delivery and hosting, various possibilities have been covered: hosted on a dedicated MOODLE™ Learning Management System (LMS) or hosted on the corporate specific LMS. Thanks to the tracking system in place, the researcher has access to general information such as the day and time of the tentative, the time spent completing the module, the quizz' results, and also the timestamp for each action of the user in the module (Figure 20). Each time the module was used by a learner, all the information on the module usage was sent to the instructor or the teacher on the morning before the lecture would start.

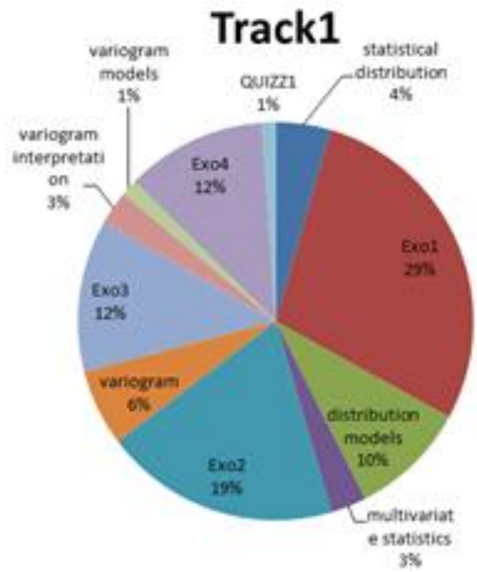


Figure 20. Example of time distribution across all the sections of the module

2.4.2. Disciplinary Content in Geostatistics and the Variogram Example

Geostatistics, which is the discipline or content knowledge in the learning situation, was funded by Professor Georges Matheron in the 50ies. Geostatistics is a science field interested in the application of statistics to spatial or spatiotemporal datasets. It enables the interpretation of spatial continuity and uncertainty. The following example considers a concept which is introduced in the tutorial: the variogram. Because the course is an introduction to Geostatistics, it is very likely that the learners discover the notion of variogram for the first time.

The variogram is a function that measures the spatial degree of data relationship. It is defined by the formula (1):

$$\gamma(h) = \frac{1}{2n}\sum_{i}^{n}\left(\Phi(u_i) - \Phi(u_i + h)\right)^2$$

where:

u_i is the coordinate in space of one point of the dataset

$\Phi()$ is the porosity function

n is the number of data pairs separated by the vector h

$|h|$ is called the lag

As it is often the case with statistical analysis methods, the variogram is formalized mathematically. However, the meaning of the equation is tightly linked to spatial considerations. Therefore, an interactive graph was used which represents, for each lag selected by the user, the pair of points selected among the experimental data of rock porosity and the corresponding isotropic variogram value (Figure 21). This facilitated the direct visualization of the effect of the lag on the pair of selected points for the construction of the histogram. Of course, a simplified example was illustrated (cf. “individual difference” principle (Mayer, 2009)) in order to allow off-loading the learner’s cognitive work for two main reasons: to stay focused on the new concept the learner is discovering (to avoid distraction, cf. “coherence” principle (Mayer, 2009)) and to keep pace by allowing other inquiries in a short length of time (the entire module is 40 minutes long!). Besides, the concept can be further developed in class with the notion of orientation of the vector, also called azimuth.

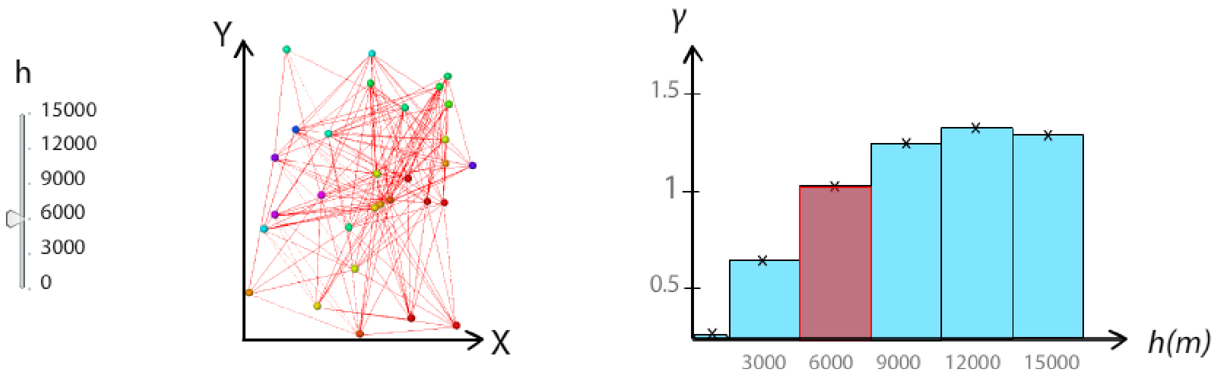


Figure 21. The variogram as it is represented in the module

This example is one among several in the module where the nature of the concept influenced the way it is represented and explained (pedagogical knowledge). In the case of the variogram, the interactivity (technology) enables to link a mathematical formula (statistics) to spatial aspects, hence allowing the learner to individually construct understanding and raise questions on what will be a basic tool for advanced estimation and simulation analysis. The learner is "embedded" within a world composed of externalized representational tools. The specificity of the module comes from the fact that the learners extend their sensorial capabilities with pictorial models made real. Visual modality and touch is relied on through user interfaces. The learners can almost feel the data and the concepts that would not be physically experienced otherwise.

Geostatistical simulation algorithms are embedded in professional software to help professional engineers off-load heavy data processing to computers ((Mayer, 2009)embedded cognition (Mayer, 2009)). Consequently, computer processing methods are hidden (black boxes) making the training of professional necessary to help them understand the automatized processes (especially for the courses at Company B and C).

Finally, the explanation is followed by an exercise where learners are asked to construct the variogram themselves in order to apply and reinforce learning.

2.4.3. The Design Process

The first phase of the study took place at the beginning of 2013, in order to design the learning resource for the purpose of the investigation. The first version of the module, also called "prototype" or "iteration 1" was designed with an instructor from company A and developed over a two week period approximately. The design process followed the organization described in Figure 22.

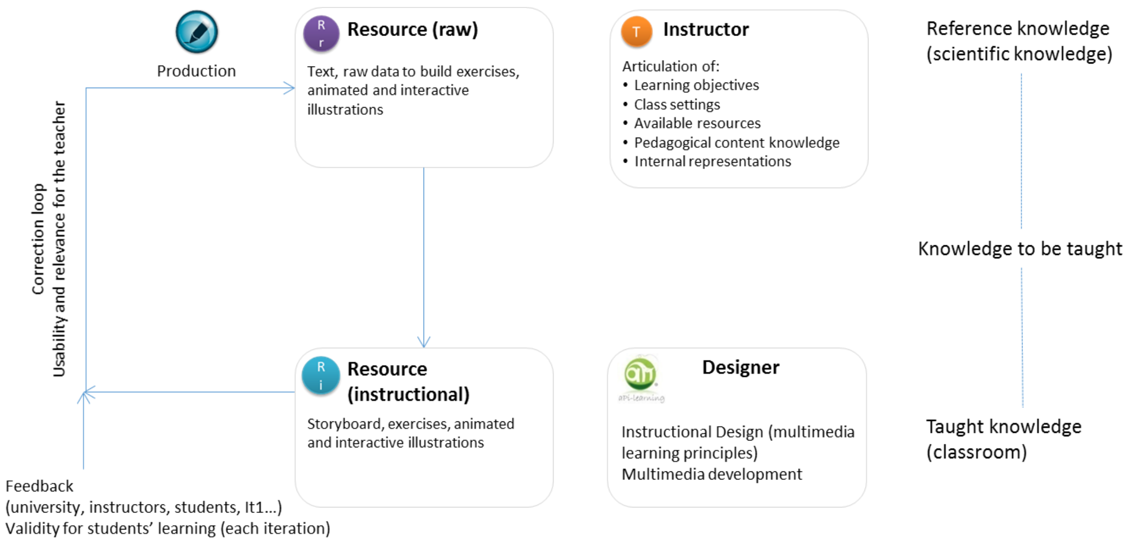


Figure 22. Physical transactions during the design process of the prototype module ("iteration 1").

The physical transactions were managed between the instructor, bearer of the pedagogical content knowledge (or craft knowledge) and the designer, who is also the researcher in the context of DBR. The designer applied instructional design principles to the design of the instructional resource. The project was managed at distance with phone calls and email exchanges as described in Table 8.

Table 8. Communication between the instructor and the designer.

Web conference	
23/04 (1h)	Kick-off, course presentation
E-mail from "designer" to "instructor"	
23/04	Request for the working document done the morning: course structure + e-learning coverage in red
30/04	Open courseware review
7/5	Designer working document with track1 description
17/5	SWF1 (structure) + request for data and images
20/5	SWF2 (advanced design of
21/05	Request for Variogram construction
22/5	SWF3 (full Track1)
24/5	Request raw data
28/5	Request Track1 correction + Day3 content
28/5	SWF4 (Track 2 with complete Estimators) SWF5 (with Track2 Simulators text) Request for exo correction
29/5	Questions + first LMS testing
30/5	Polishing of module + exercises SWF6 (Track2 to review)
31/5	LMS accounts activation
3/6	Sending of final survey
E-mail "Instructor" -> "designer"	
23/04	Sending of course structure + Day1
7/5	Day1 + image
17/5	Material Day1 (points + stats)
21/5	Material Day1 (Variogram)
22/5	Material Day1 (Illustrations Variogram + paper on variogram + Regressions)
28/5	Day3 Material Day3
29/5	Material Day3
30/5	Correction Track1

Short calls along the way (<5mn)

The module has been implemented and improved iteratively with companies and universities (see Figure 23).

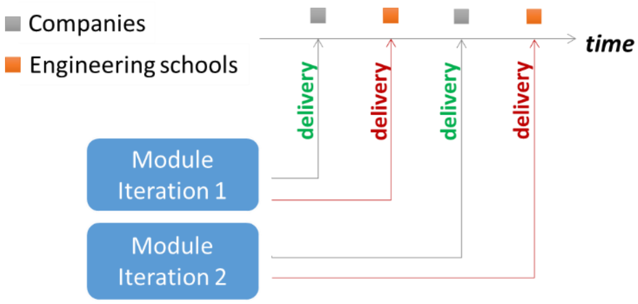


Figure 23. The e-learning design process: an iterative approach

For each iteration, the module has been enhanced and also adapted to the course constraints of the "client" institution (see Table 9 and Table 10).

Table 9. Main features of the different iterations of the module.

Iteration	Features	Reason
1	Pilot module. Flash™ technology, voice-over, interactive features, embedded exercises	
2	Improved exercises, SCORM 1.2 version with tracking	The objectives of the assignments were not well formulated within the Excel spreadsheets. The navigation system was improved, a natural voice over, two self-assessments at the end of chapter 2 and 4 were added as well as a complete tracking system in order to follow the users' interactions.
2_quizz	Enhanced quizz, exercises were not tracked (flaw)	The teacher at the IFP School asked for quiz improvements. The opening of the Excel files was not tracked properly.
2_bisSCORM	Correction patch for 2_quiz	Correction of a flow: Exercise 6 has been sent as Exercice5.
3_krig+total	Improved version with corrected Simple Kriging exercise and the modifications suggested by the review of Total's professionals	Improvements requested by professionals
4Geovar	Improved version with the modifications suggested by the review of Geovariances's professionals	Improvements requested by professionals

Table 10. Use of the different iterations of the module across the different courses.

Phase of the research study	Course Code	Institution	Module iteration	Delivery mode: "two tracks" or "full module"
I	1	Company A	1	two tracks
	2	University A	1	full module
	3	University A	1	full module
	4*	University A	1	full module
	5	University A	1	full module
II	6	Company A	2	two tracks
	7	University A	2_quiz	two tracks
	8	University A	2_bisSCORM	full module
	9	Company B	2_bisSCORM	full module
	10	Institute A	3_krig+total	full module
	11	Company C	4Geovar	full module
	12	University B	4Geovar	full module

*optional: available online for consultation, was not part of a blended course

As previously said, the module could be split into two different tracks in order to adapt to the program of the course.

The first version of the module, called “iteration 1”, was implemented in parallel with class lectures for blended learning at one multinational company and at one engineering school. Feedback was collected from the instructors, the teachers and the students and the e-learning content was improved at the end of 2013.

2.4.3.1. Instructional Design and the Choice of Technology

This part discusses the choices of technology that have been made to support learning in the particular context of the study. Hereafter some of the choices made are exposed concerning technology selection (software) and also concerning interactive activities.

The module is a tutorial which can be accessed from the web via a Learning Management System (LMS) directly from the workplace, from the school facilities or from the home place. The technology selection has been done against two main criteria.

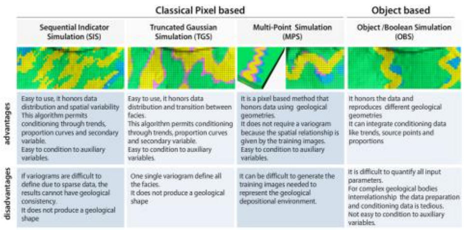
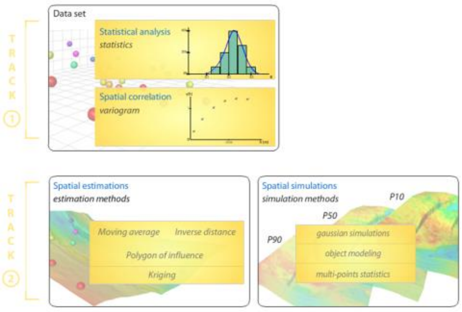
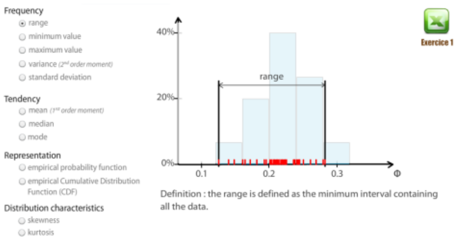
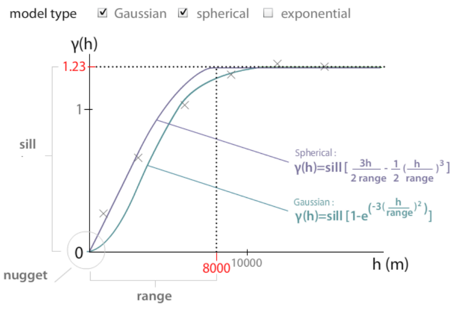
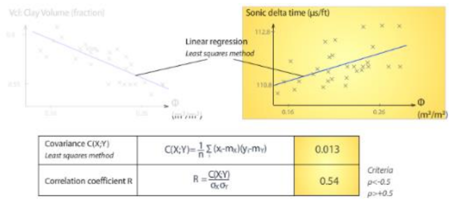
First, the learner would have to access the learning resource without further software installation (particularly in companies for security reasons).

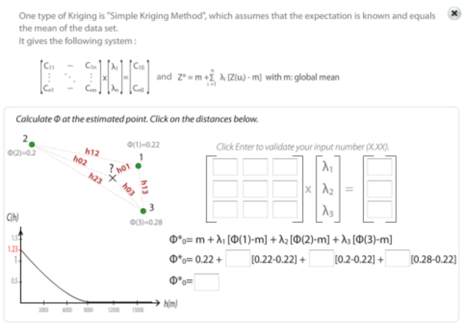
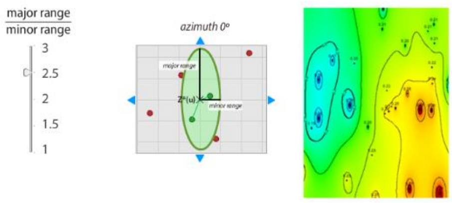
Second, the technology would have to allow advanced interactive instruction. Therefore, the resource was developed with FLASH® technology. Indeed, given the population of targeted learners, it was considered that in their academic or professional environments, engineers would most likely work from a Personal Computer (PC) with Flash Player already installed in their browser. This represents the first “E” of the 4-E model where the environment is compatible with the technology selection (Collis & Moonen, 2001).

Regarding the 2D & 3D graphics, they were designed either from instructor’s drawings, available graphs, from the dataset itself, from Excel® spreadsheet or from simulation results.

The module includes many interactions in order to make the learners active and allow them to almost “touch” the data and concepts (see Table 11).

Table 11. Instructional methods used in the e-tutorial following the Multimedia Learning framework (Mayer, 2009).

Presentation mode	**Knowledge structure**	**Example**	**Comment**
Text	Comparison	Simulation table 	Similar to a book-based environment
Narration and animation	Presentation	Structure of the module 	Similar to transmission in class
Texts and annotated illustrations + interactivity	Classification	Statistics 	Similar to a book-based environment made interactive
Texts and annotated illustrations + interactivity	Comparison	Variogram models  Covariance and correlation coefficient of positive and negative correlated systems 	Similar to a book-based environment made interactive

Texts and annotated illustrations + interactivity	Application	Simple Kriging practice 	Similar to a software-based environment
Texts and annotated illustrations + interactivity	Influence study	Influence of major/minor range on the moving average method 	Study of a parametric influence, sensitivity study (cognitive tool)

- Radio and check buttons: radio buttons are used to allow the learners getting access to dataset characteristics for statistical analysis. Radio buttons make the module flexible around the needs of the learners. Users are not forced to follow a given track of explanations. Check buttons are used to display mathematical models on top of the experimental variogram diagram for instance. It allows the learners to make quick and detailed comparisons between the dataset and the models of their choice.
- Sliders: the previous part described how the variogram introduction relied on slider interactions. Indeed, sliders allow parametric sensitivity study. As way of example, sliders were also used to explain estimation methods. The "major / minor range ratio" parameter was used to visualize its influence on the estimation results,
- Clickable graphs: the learners have the possibility to directly click on graphs in order to display further information related to the graph and understand the math behind.
- Input texts: they are used in one exercise where students have to use the "simple Kriging method". They have to fill a matrix system from spatial information available on screen. The false entries are in red and the right ones are in green. It allows live auto correction and guides the users for concept reinforcement. Input text is also used to collect users' feedback when they exit the module. It allows feedback collection at the moment students complete the tutorial activity.

Table 12 presents a description of the kind of tests used throughout the e-tutorial. A variety of exercises were applied in order to assess both knowledge retention and knowledge transfer.

Table 12. Description of the tests used throughout the learning resource.

Kind of test	Type of question	Activity
Retention	Description	Quizz 1&2
Transfer	Conceptual, prediction	Variogram exercise (embedded)
	Redesign	Simple Kriging exercise (embedded) Excel based exercises

2.5. The Data Collection Methods

Figure 24 details the origin of the quantitative and qualitative data available for the study: the questionnaires, the semi-structure interviews and the online system used to track users' interactions.

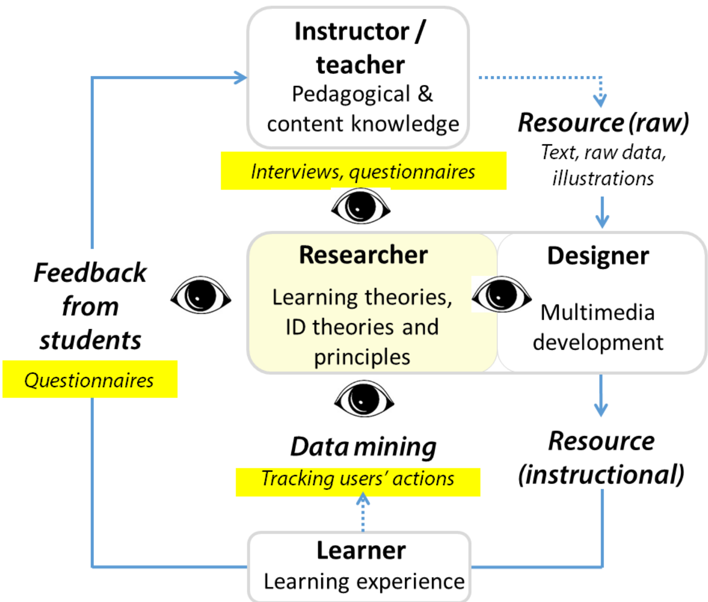


Figure 24. Illustration of the mixed methods used for data collection (highlighted in yellow).

The instructors, the teachers and the learners were given the questionnaires, in paper format, at the end of the last training session. The questionnaires aim was collecting people's statements regarding their attitude, expectations and satisfaction towards e-learning. The questionnaires measure categorical, continuous and discrete variables. Most of the true ordinal variables related to subjective rating (such as the users' level of satisfaction) were measured with five-level Likert items and have been treated as discrete variables for their use in statistical analysis (Field, 2012).

The tracking system allows to record all the information related to the users' interactions. Timestamps were collected, that is to say, the time corresponding to every action such as a mouse click, the selected object, the chapters of the module which have been entered or the opened exercises. This information is particularly useful to understand how the module is being used by the learners.

2.5.1. The Questionnaires

2.5.1.1. The Questionnaire for the Learners

Pilot questionnaires

During the first phase of the study (prototyping), three types of questionnaires were used: one for the students, one for the employees and one for the instructors (see Appendix 2, Appendix 3, Appendix 9).

As far as the methods used in a DBR can vary during the different phases of the study (Wang & Hannafin, 2005), the primary aim of the pilot questionnaires was to get the Subject-Matter Experts' (SME) feedback along with the learners' feedback on the accuracy and completeness of the content of the prototype version of the module (iteration 1) and to refine the design of the research methods in order to reach the research goals. Indeed, at this stage, the focus of the research was the design confirmation and refinement. All of the pilot questionnaires were one page long, with less than 10 items. The "instructors" questionnaires were distributed via email as an attached PDF file. The "learners" questionnaires were paper-based at companies and web based at schools (using the SurveyMonkey™ tool).

Regarding the questionnaires for learners, they were asked if they had prior experience with blended learning, their global satisfaction level and comments, if they thought the e-learning usage should be arranged during training time, if it was fair to ask its completion out of class or if they had other opinions. In addition, they were asked to rank 10 e-learning characteristics from the most to the less important. For the prototype module, they were asked to evaluate each characteristic from bad to very good. Finally, the learners had to say whether they agreed with four different assertions on the utility of e-learning. Learners could make their own recommendations at the end of the survey.

Employees were asked additional questions like the reason of their registration to the training, and whether the discipline was new to them.

The results, presented in Appendix 5 (see Appendix 4 for the codification), show an insufficient return rate for the online survey. Whereas 100% employees filled in the paper-based questionnaire at the end of their training session, only 10% of university students filled in the online survey. Given the very small amount of university feedback (see Table 7) and the need to further detail the questionnaire, two new paper-based questionnaires were designed for Phase II of the study, one for the instructors and one for the learners. All questionnaires had to be filled in by the students during the last training session. This significantly improved the average return rate from 18% to 76% on average between Phase I and Phase II.

The pilot questionnaires resulted to be useful in order to collect users' feedback during the prototyping phase. The early feedback informed both the instructor and the e-learning designer (also the researcher) on the user experience and the strengths and weaknesses of the original design. First, the global satisfaction was high with 13 learners either satisfied or very satisfied. However, considering the validity of question QL2 it appeared that some learners gave their opinion on the whole course rather than on the specific e-learning. Besides, the introductory tutorial was considered "useful", "easy to understand" and "very enjoyable".

Some students' appreciations, either expressed in the questionnaire or directly to the instructor, guided the decisions made for the design improvement. For instance, the navigation system was totally revised to address difficulties some learners faced, employees asked for assessments at the end of each track, and it was suggested to review the e-learning exercises in class to reinforce the concepts understanding. Considering the delivery, employees faced some issues to login from the company's network. For the later courses, the module was made available directly from the corporate LMS.

The main difference found between both populations is the sense of usefulness expressed by employees. Employees wrote that they "have" to improve their skills to perform their job better, and that they "need to understand the concepts of Geostatistics for (their) project".

Reviewed questionnaires

The questionnaires for the main phase of the study (Phase II) were designed with the help of a faculty member, professor of research methodologies and diagnostic tools in Education, at the Faculty of Education of the Complutense University of Madrid. In addition, the validity and reliability of the questions were reviewed by six professionals (see Appendix 7, Appendix 13):

- from the e-learning field (Educational Consulting in e-learning / TU Delft, Instituto de Ciencias de la Educación / Universidad Politécnica Madrid),
- from the engineering education field (Teaching and Learning Department / KULeuven, Aerospace Structures & Computational Mechanics / TU Delft),
- from the research field (Manufacturing Industry Education Research / University of Cambridge)

The learner's questionnaire was kept anonymous in order to encourage learners to participate and maximize the return rate, especially given the small population of corporate learners. The validated questionnaires for learners are in Appendix 8. The results obtained with the final questionnaires are analyzed in the following parts of the paper.

2.5.1.2. The Questionnaire for the Teachers

Considering the questionnaires submitted to the teachers, the same validation process has been followed (see Appendix 9 "Pilot", Appendix 10 "Codification", Appendix 11 "Results", Appendix 12 "Open questions", Appendix 13 "Review", Appendix 14 "Validated"). The results obtained with the final questionnaires are analyzed in the following parts of the paper.

2.5.2. The Interviews

Interviews were conducted in order to understand people's practices, attitudes and values with respect to teaching, learning, scientific & engineering subject-matter knowledge and technology-enhanced learning.

The interviews were semi-structured and audio recorded.

Table 13. Interviewed people.

Institution	Department /Faculty	Person	Date	Function	Iteration
REPSOL	CTR	A	06/03/2013	Earth Modelling Advisor, instructor	#1
IFPEN	Geology / Geosciences	B	06/04/2013	Head of Geology department, former instructor at IFP-school, current instructor at IFP-school, current instructor at the Technical University of Petronas in Malaysia.	#1
IFP-school	Exploration Production	C	06/04/2013	Lecturer, teaching Geology and Reservoir Modeling, professor at IFP-school	#1

The categories of questions, given in Appendix 15, were centered on five main topics: the instructor, the content, the learner, the learning resources, and the methods of instruction.

The interviews were particularly useful to get familiarized with the discipline and the corresponding teaching practices. It highlighted the fact that professional software usage is common in the teaching of Geostatistics, given its data processing nature.

2.5.3. The Module Tracking System

No tracking system was in place during Phase I, and only the connection time and duration were available (standard LMS information). Then, from Phase II, information was collected on the user's experience. All timestamps corresponding to interactions were recorded for every attempt of each user: start of the module, entrance to each sub-chapter, opening of an Excel™-based assignment, and all embedded exercises or quizz responses (see Appendix 16).

3. RESEARCH RESULTS AND ANALYSIS

This chapter first describes the research results collected from the teachers and from the learners. The second part builds a model of blended learning in EE from the research observations and results.

3.1. Application of Blended Learning with a Shared Digital Learning Resource in Engineering Education

This first section reviews the main results obtained from the teachers and from the learners.

3.1.1. The Teachers' Perspective

The main descriptive statistics are presented in Appendix 20 and Appendix 21.

In total, one training manager in geosciences and 11 instructors in Geostatistics answered the questionnaire, of which two were faculty members at university and nine were trainers from the industry. This section will analyze the feedback from the 11 people who completed the validated version of the questionnaire, that is to say, two teachers, eight trainers and the training manager. Out of them, one trainer and the training manager belonged to different institutions than the one listed in Table 7.

On average, faculty members have seven years of work experience using Geostatistics and one year of teaching experience. Instructors have 13 years of work experience using Geostatistics (Min = 1.5, Max = 30) and eight years of experience in teaching Geostatistics (Min = 1, Max = 25). The university teachers teach at master's level. All professional trainers teach at professional level and 37% of them also teach at master's level. All instructors use professional software to support their teaching in Geostatistics. Both teachers and only one instructor received training in Instructional Design (ID) or in learning theories. Nonetheless, none follow any particular theory or methodology to design their course.

The willingness to use the e-learning module is significantly related to the capacity to assess students' knowledge before class ($r = .59$, $p = .027$), the possibility to get students prepared for the class ($r = .73$, $p = .005$), the improvement of teaching during class ($r = .64$, $p = .017$), the time saving for class ($r = .7$, $p = .008$) and the helpfulness to illustrate complex concepts ($r = .53$, $p = .047$).

Among the 11 instructors and teachers who answered the questionnaire, none of them had used e-learning during their course prior to this design experiment. Interestingly, the module is still in use in one engineering school for blended learning (two professors use the learning resource in their course) and in two different companies for blended and distant learning.

During the research, no prescriptive rules in the usage of the e-tutorial were delivered to the teachers and the instructors. Each teacher or instructor had the freedom to make their own usage of the module for their class. This resulted in very diverse modalities of usage of the e-learning itself but also in the way traditional class was conducted.

In some cases (course 6 and course 7), the module was delivered in two sub-modules, also called tracks. Each track had to be completed by the students for two different class sessions. For course 10, a four-day training session, each of the fours chapters was requested for the corresponding day of class. All the other courses used a full version of the module requested prior to class, except course 8, which was delivered between an introductory class and a workshop. The instructional delivery is polymorphic in the sense that a single learning resource can generate multiple chronological scenarios of usage.

In addition, in the case of e-learning usage prior to class, some modifications were observed in the way traditional class was delivered. For instance, one teacher at the university used the quizz results sent the morning of each session by the researcher in order to trigger discussion directly from the beginning of the lecture. It could be argued that the introduction of the e-tutorial facilitated the adoption of innovative learning practices. In the previous example, the teacher naturally used the available information on students learning in order to activate class discussion. Interestingly, the e-learning module was also used during class. It was the case of an instructor at company A, who made a detailed review of the exercises in class. This practice illustrates a synchronous usage of e-learning. In this case, the exercises were reviewed in class for reinforcement and extra scaffolding provided by the inter-personal exchanges with the peers and the instructor.

In the context of the study, grades were made available to the teachers. However, e-learning scores have not been used to grade the learner's results in either case. Although e-learning has been presented as a course activity in its own right (Appendix 28), no teacher has decided to use the quizz results for grading. All the teachers and instructors considered the tutorial as a tool at the service of the learner, for his/her own preparation and self-assessment.

Interestingly, the findings showed a negative correlation between the instructors' number of teaching years in Geostatistics and their intention to use the e-learning module for their course (r = -.87, p = .001, BCa 95% Confidence Interval= -.99 to -.54 and Kendall's value τ is .774 with p=.004 and BCa 95% Confidence Interval= -.95 to -.33, see Figure 25).

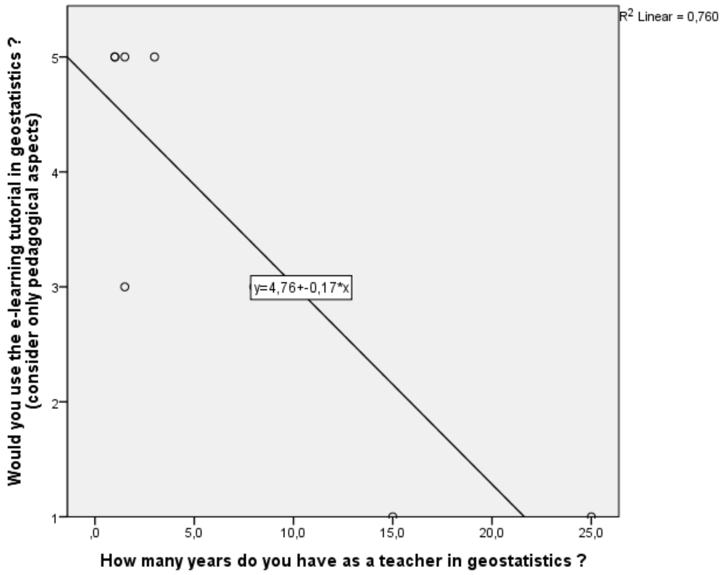


Figure 25. Relation between the experience in teaching and the propensity to use the e-learning tutorial

The coefficient of determination R2 is equal to 0.76, meaning that 76% of the variability to adopt e-learning is shared by the instructor's experience in teaching.

Overall, four teachers or instructors are very likely to use the e-tutorial in the future, two are likely and three may use it during their class. The two most experienced instructors, who have 30 years' experience using Geostatistics and 15 years and 25 years teaching it respectively, are the only two respondents very unlikely to use the e-learning tutorial in their class. One of them explained that the module was too concise and too ambiguous between the experimental and model variograms, while the other respondent, who teaches professionals only, claimed that it is not realistic to expect such an implication from professionals due to their commitment to their job.

To finish, teachers were asked on their opinion on university-business collaboration for the design of course material in Geostatistics. Table 14 provides the main results among 13 statements.

Table 14. Analysis of teachers' opinion on UBC

	Learners
Agree (> 4)	The industry can bring authentic/real world challenges necessary to create engineering minds It will help to get various perspectives and it will contribute to enrich the teaching content (around 4)
Disagree (< 2)	This will never happen because my institution does not have any relationship with academia or industry The collaboration will fail. Teachers and professionals do not share the same culture (public/private sector) I am not used to working in team.

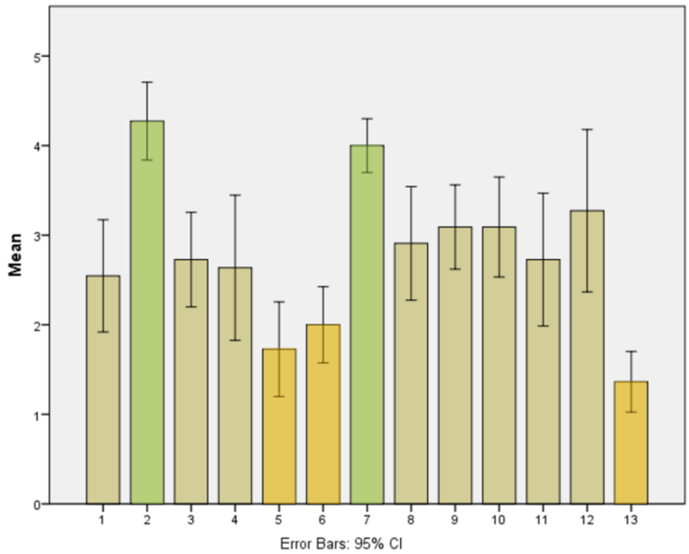


Figure 26. Instructors' level of agreement with the 13 statements on UBC

From the perspective of the teachers, the following observations can be advanced considering the research questions.

First, regarding the e-learning usage, the results show that the same resource has successfully been used and is still in use within academia and industry. Indeed, two companies and one HEI still use the resources for their courses in Geostatistics. Interestingly, it has been observed that the learning resource is used differently depending on the teacher and on the course structure. In addition, the application of this additional learning activity for blended learning modified the teaching practice.

Second, the following factors influence the application of a common learning resource within academia and industry. The fact that the activity was conducted as a research project may have contributed to the participation of so many stakeholders, lowering the effect of competition and IP protection. Another factor for e-learning application is the number of years of experience of the trainers. The higher the experience, the less the instructor is willing to apply e-learning. Although it is not statistically significant given the small size of the sample, at this stage, it is suggested that this reluctance comes from preconceived ideas and resistance to change the training practices. Moreover, experienced trainers think employees do not have time for e-learning. Considering the applicability of such resources made from UBC, trainers think their institution already have the right connections to develop UBC and they do not think that the difference of culture between universities and businesses is an obstacle to UBC.

Finally, considering the design of common LR, it was observed that teachers may be trained to ID but do not use any particular framework. A specific ID methodology might be useful to guide UBC in EE. Instructors believe that UBC helps to get various perspectives and contributes to enrich the teaching content. In particular, instructors believe industry can bring real life cases for authentic learning. However, it is not clear how this material would be introduced in the learning resource.

3.1.2. The Learners' Perspective

This section is divided into two parts. The first part describes how the module has been used by the students, and the second analyzes students' feedback.

3.1.2.1. The Blended Learning Experience at University and in the Companies

This section studies the information collected from the learners via the web analytics (see Appendix 16, Appendix 17, Appendix 18, Appendix 19). Out of the 103 learners (79 students and 24 employees), 87 learners used the module. This represents a completion rate of 84% overall which is composed of 83% of students and 87% of employees, 101 hours of online learning and a mean duration of usage of M = 69 min, 95% CI [59, 79]. Even if on average, employees used the module for 77 min and students for 67 before class delivery, no statistically significant difference has been found between universities and businesses (see Figure 27, and Table 15). Whereas 93% of students completed the e-learning in the evening or during the week-end (78% at home), 59% of employees did the e-learning during working hours (68% at the workplace).

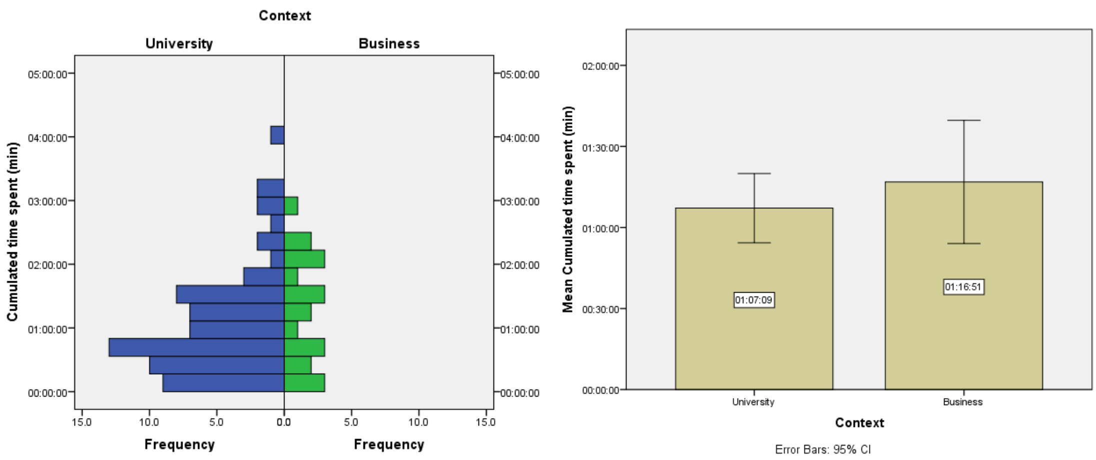


Figure 27. Dispersion of the cumulated time spent by each group

Table 15. Table of the cumulated duration of the module usage per course.

Phase	Course Code	Institution	Number of users	Usage duration (total)	Usage duration (average/learner)	Usage duration (SD/learner)
II	6	Company A	6	5h25	54min	31min
	7	University A	30	37h31min	75min	45min
	8	University A	29	29h18min	60min	55min
	9	Company B	4	7h12min	108min	48min
	10	Institute A	5	6h50	82min	52min
	11	Company C	6	7h26	64min	48min
	12	University B	7	7h02min	60min	58min
Total			87	101h	69min	51min

Code	Title of the section in the tutorial
Part11	statistical distribution
Exo1	Exo1
Part12	distribution models
Part13	multivariate statistics
Exo2	Exo2
Part21	variogram
Exo3	Exo3
Part22	variogram interpretation
Part23	variogram models
Exo4	Exo4
Part24	QUIZ1
Part31	moving average
Exo5	Exo5
Part32	polygon of influence
Part33	inverse distance
Part34	kriging technique
Exo6	Exo6
Part41	Simulation for discrete prop
Part42	Simulation for cont prop
Part43	QUIZ2

**Part24 includes quiz#1 and part43 includes quiz#2*

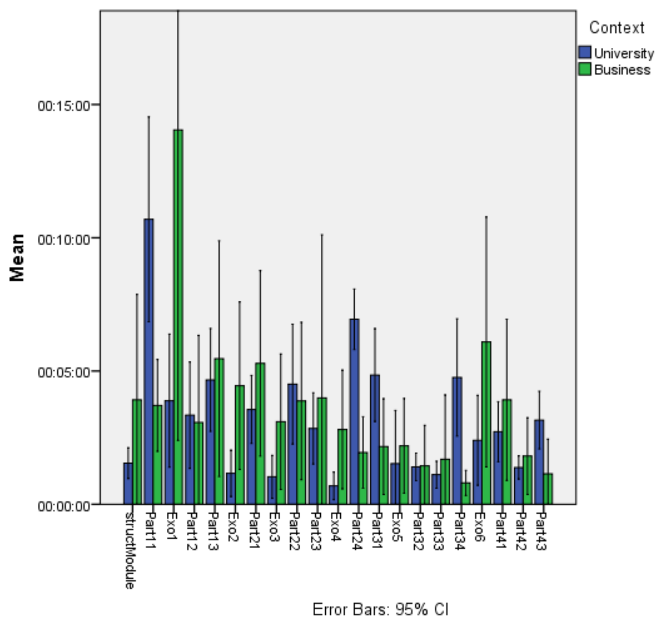


Figure 28. Cumulated time spent on each part of the module.

From Figure 28 it can be observed that the time spent on Part43 is underestimated. Indeed, although the timestamp corresponding to the action of accessing this part has been studied, nonetheless, in some cases, the user directly exited the module without using the exit button of the module. In these cases, it resulted impossible to calculate the accurate time spent on this part.

Overall, university students dedicated more time on quizz while business learners dedicate more time on exercises. Below are the results for the two embedded quizz. Although the number of attempts was unlimited, only the first attempt results were kept for the study.

Table 16 shows the proportions of the users who completed the quiz. The quizz were changed between course 06 and course 07, consequently, the results shown in Figure 29 do not take into account course 06. The completion rate of the two embedded quizz is 91% for students and 67% for employees. The difference of scores between students and employees is not statistically significant. Thus, it can be considered that both populations scored the same.

Table 16. Proportions of quiz completion.

	Course	N learners	N users	N QUIZ1	N QUIZ2
University	07	30	30	29	23
	08	42	29	29	29
	12	7	7	7	6
	TOTAL	79	66	65	58
Business	09	6	4	4	4
	10	6	5	2	2
	11	5	5	3	3
	TOTAL	17	14	9	9

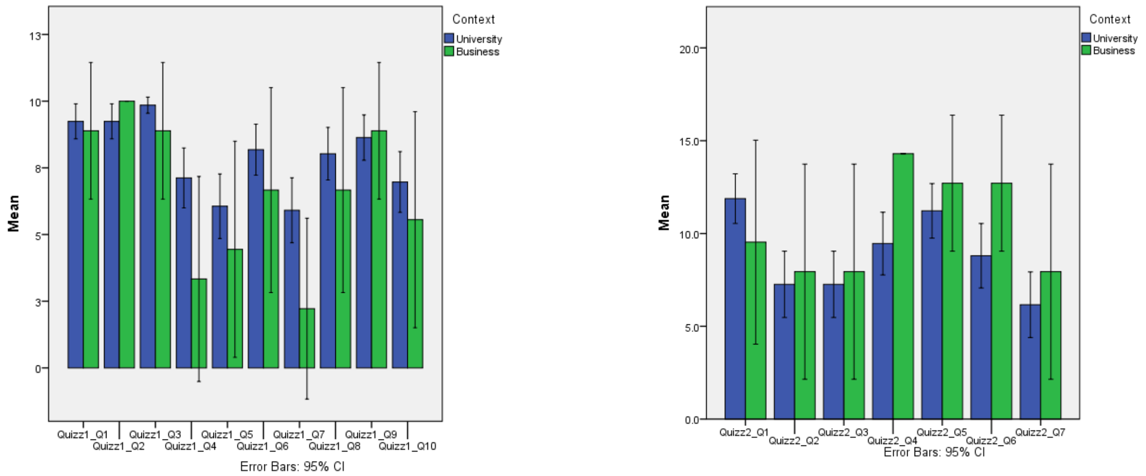


Figure 29. Results for the two quizz.

As has been previously detailed, the results of the quizz are not used for corporate reporting nor for learner's participation.

3.1.2.2. The Academic and Corporate Learners: their Profiles, their Satisfaction, and Expectations towards Blended Learning

The main descriptive statistics are presented in Appendix 23 (codification), Appendix 24 (all), Appendix 25 (University), and Appendix 26 (Business).

In the questionnaire, various items were aimed at collecting information on gender and age. Table 17 gives the results obtained for universities and businesses.

Table 17. Demographics

	Population			**Respondents**							
	Number of learners	**Gender**		**Gender**			**Age**				
		% male	% female	N	% male	% female	N	Min	Median	Max	SD
University (course 7+8)	79	74	26	55	71	29	56	1 (<23)	2 (23-25)	6 (40-44)	1
Business (course 6+9+10+11)	24	46	54	20	45	55	20	1 (<23)	5 (35-39)	7 (45-49)	1.6

In the context of this study, the size of the populations of learners at universities is larger than in companies. The average course size is 26 students in the engineering schools in comparison to around six people in corporate training.

At University A, males represent over 70% of the students, whereas at businesses, the distribution of gender is random. Regarding gender, the population of respondents is considered representative of the population of learners. Indeed, 71% of university respondents were males and 74% of the university population were actually males. Considering companies, 54% of employees were females with 55% of respondents being women.

The age distribution has been measured on a 10-point rating scale. The average age is 23 to 25 years old for students and 35 to 39 years old for employees (see Figure 30).

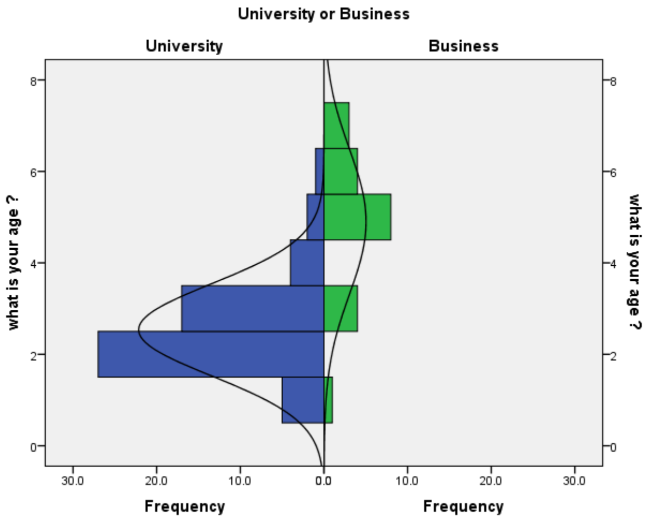


Figure 30. Histogram of age for university and business

For 69% of the respondents, the introductory course in Geostatistics was their first training in the field. In addition, the combination of e-learning and classroom sessions for a single course, the so-called blended learning in the context of the research, was new for 77% of the population. More precisely, 27% of students already used blended learning beforehand while only 14% of employees did. The proportion of students having used blended learning in previous courses is almost double that of employees. However, it is fair to say that the blended learning approach is not generally adopted in the institutions which participated to the study.

In addition, five-level Likert items were used to measure the preferences of the learners. Considering the e-learning tutorial, students (M = 3.7), are significantly more satisfied than employees (M = 3.34), U = 430, z = -2.06, p = .039, r = -.23 (with a small to medium effect size). In addition, the amount of learning is said to be significantly higher by students (M = 3.7) than employees (M = 3.3), U = 423, z = -2.0, p = .038, r = -.24 (with a small to medium effect size).

Besides, global satisfaction is found to be related to the perception of the amount learnt (see Figure 31). The coefficient of determination R2 between the two variables is 0.33 for university and business together. Interestingly, there is also a significant relationship between the global satisfaction level and the fact that learners think the module made them confident to participate in class (r = .36, p < .005, BCa 95% Confidence Interval = .14 to .56 for students, r = .54, p < .007, BCa 95% Confidence Interval = .22 to .75 for employees, see Figure 31).

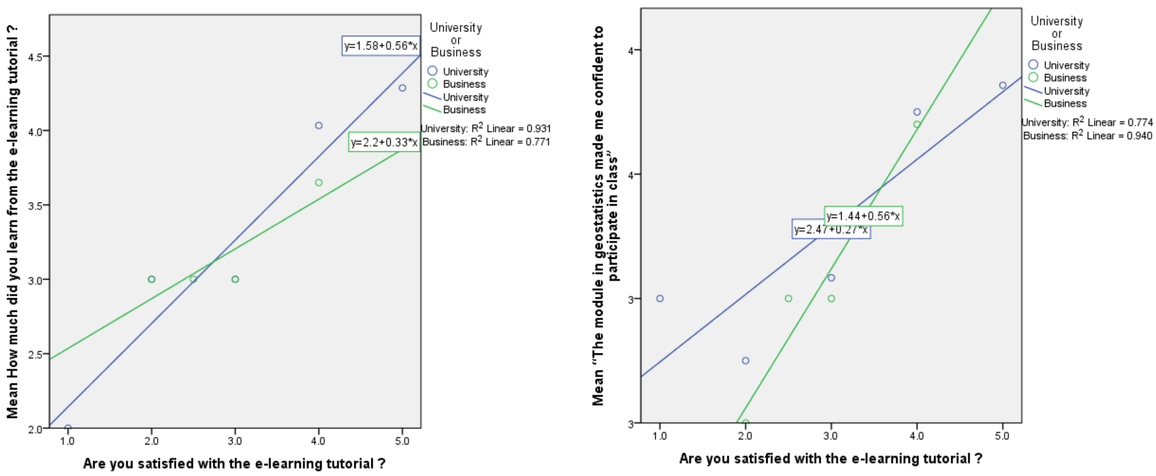


Figure 31. Variables related to general satisfaction

Finally, while 57% of the students can estimate how often they will use what they learnt, 68% of the employees estimate they will (see Figure 32). This measure is called the "perceived usefulness".

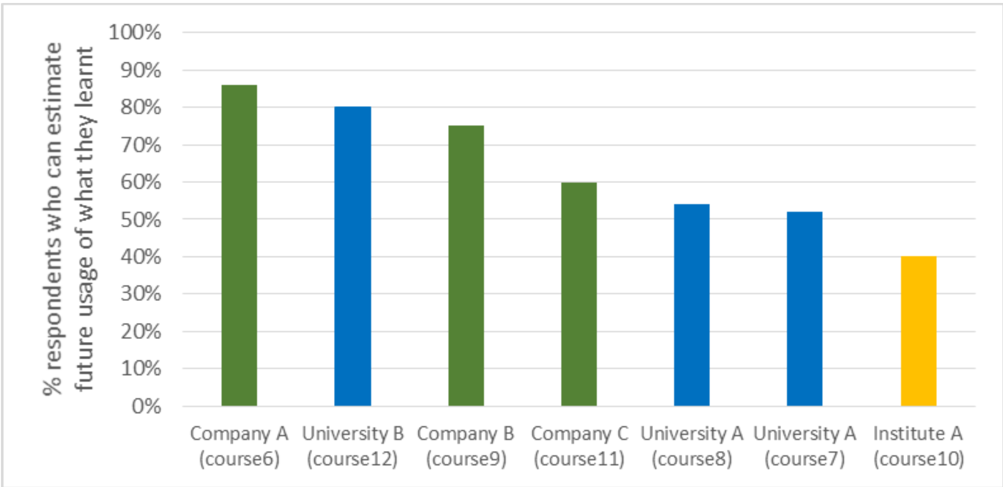


Figure 32. Dispersion of the perceived "usefulness" across courses

In addition, learners were asked how much time they would spend to prepare for one day of class. This was used to measure "dedication to learning". There is no statistically significant difference of means of time learners are ready to spend between university (N = 52) and business (N = 21) ($p > 0.05$). On average, all learners, from academia and industry, are ready to spend (M= 46 min, 95% CI [39, 53]) respectively 44 minutes in the case of students and 51 minutes in the case of employees (see Figure 33). It is noticeable that the mean of usage duration, M= 69 min, 95% CI [59, 79], is higher than the time learners are ready to dedicate for self-study before class. No correspondence can be drawn between what one particular learner said would be their time dedication and the actual usage duration because the questionnaires were anonymous.

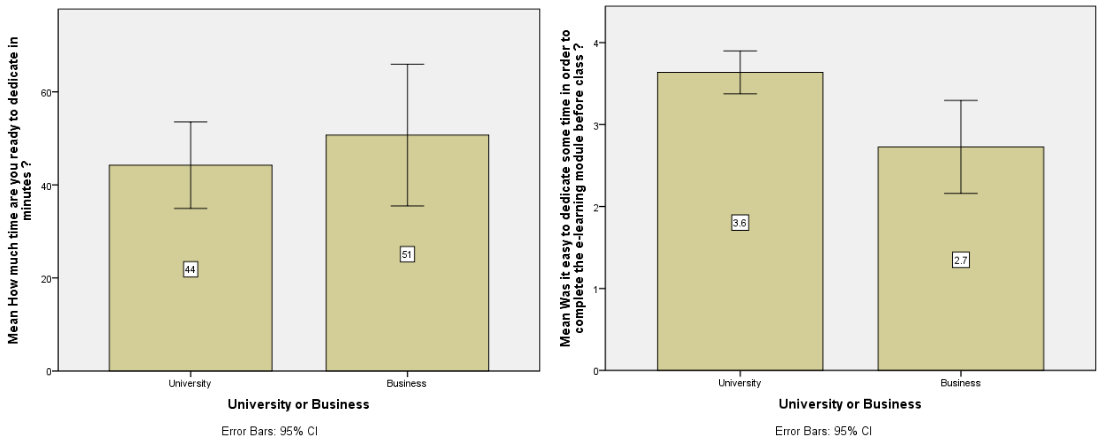


Figure 33. Time dedication and time constraint

Considering the capacity to dedicate some time to self-learning, they were asked if it was easy for them to complete the module on a five-point rating scale (see Figure 33).

For this purpose, the Mann-Whitney test was used to compare the two independent conditions (the academic and professional context). For students (Mdn = 4), it was significantly easier to dedicate some time than for employees (Mdn = 3), $U = 351$, $z = -3$, $p = .003$, $r = -.34$ (medium effect size). Consequently, it is observed that even though employees claim they have more difficulties to find time for self-study, they do provision and dedicate the same preparation time than students. Interestingly, no significant relationship has been found between the global satisfaction and the easiness to dedicate time to preparation.

Considering the qualitative results, the first step was the analysis of the learners' verbatim collected via the questionnaires (see Appendix 27). The items fall in two different categories: a) related to the learning content, and b) related to the e-learning module (see Table 18).

Table 18. Main qualitative feedback per category. Collected from the questionnaires for learners (N=78).

	Learning content	**E-learning**
Strengths	Short explanations, summarized Easy, simple Well explained Clear "Provides details on basics I would not dare to ask" Good exercises	Easy to use Very interactive Illustrative Well organized, good presentation quality Self-assessment (Quiz), self-learning, convenient Adapted to three day class
Weaknesses	Too short, more explanations are required, reference books, recalls on statistics (attached file) Can be simplified Add applied examples from the company	Not easy to use (issues with opening Excel from company network) Add more interactive explanations, more exercises with instantaneous feedback Inform better and earlier on blended format Scaffolding: can't ask teachers about the exercises, need to ask some questions E-learning and class should not replicate the same teaching Took longer than 40min

These two categories include some contradictory feedback depending on the respondent. The conciseness of the module explanations and the level of complexity of the learning content is subject to users' appreciation. Some users considered the conciseness of the module to be a strength and others a weakness. At this stage, a path model with causal effects is missing between variables in order to explain how these preferences are linked to other observed variables and personal attributes.

3.1.2.3. The Three-Factor Model and the Difference between Academic and Corporate Learners

In the context of the study, there is interest in determining how well the items relate to each other in indicating learner's attitude towards the e-learning module and more generally towards blended learning. The initiative to run an Exploratory Factor Analysis (EFA) was taken in order to better understand the structure of the available data in the context of the study. The primary intent is to identify potential differences between students' and employees' perception about e-learning. Given the epistemological positioning of the research and the limited size of the purposive samples, no statistical generalization of results is expected. However, understanding the possible relationship between explanatory factors for the whole population of learners, both students and employees was deemed opportune. Doing so, the EFA would be run on the greatest possible sample size. Then, the factor scores would be studied for each population separately in order to identify possible differences between students and employees against each latent variables. The objective of the EFA is to explore the data and to identify clusters of variables that would represent explanatory constructs, also called factors or latent variables that cannot be measured directly. Doing so, the data set is reduced to a more manageable size while retaining as much of the original information as possible (Field, 2012).

A principal axis factor analysis was conducted on the 13 selected items with orthogonal rotation (varimax). Orthogonal rotation was applied because there is theoretical reason to suppose that the factors are fairly independent. To confirm this statement, an analysis was conducted with oblique rotation which resulted in similar analysis and in uncorrelated factors (see Table 19). Consequently, the assumption of independent constructs is confirmed. The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis, KMO = .634 (above "mediocre" according to Hutcheson & Sofroniou, as cited in Field (2012), and all KMO values for individual items were above the acceptable limit of 0.5 (Field, 2012)). An initial analysis was run to obtain eigenvalues for each factor in the data. Four factors had eigenvalues over Kaiser's criterion of 1 and in combination explained 58% of the variance. The scree plot showed an inflexion point at factor 4. Retaining 3 factors was decided because of the limited sample size and the convergence of the scree plot and Kaiser's criterion on Factor 4. The first three factors in combination explain 50% of the variance. Table 20 shows the factor loadings after rotation. The main data of the previous analysis is in Appendix 29.

Table 19. Factor correlation matrix in the case of an oblique rotation

Factor Correlation Matrix

Factor	1	2	3
1	1.000	.157	-.012
2	.157	1.000	.011
3	-.012	.011	1.000

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.

Table 20. Summary of EFA results for the questionnaire (N = 73)

Rotated Factor Matrix[a]

Item	Factor1	Factor2	Factor3	Label
Are you satisfied with the e-learning tutorial?	**.794**	.033	.047	Satisfaction
How much did you learn from the e-learning tutorial?	**.636**	.231	-.042	learning_Amount
"The module in Geostatistics …makes me confident to participate in class"	**.504**	.189	.101	made_Confident
"An e-learning tutorial should…the completion of the module should count for my grade"	**.475**	-.122	.086	should_Count_Grading
"The module in Geostatistics …is exhaustive, with all the same detailed explanations as in books"	**.401**	-.102	-.030	is_Exhaustive
"An e-learning tutorial should…create interaction with the data, with the key concepts"	-.058	**.867**	.035	Interactions
"An e-learning tutorial should…explain the main concepts and their relationships"	-.110	**.523**	.232	explain_Concepts
"An e-learning tutorial should…include exercises with feedback for self-assessment (quiz)"	.327	**.438**	-.146	exo_Feedback
How much time / scale	.242	.244	**.583**	prep_Time
"An e-learning tutorial should…provide a printable file for future inquiries"	.072	.011	**.527**	Printable
Age (5 points scale)	-.113	-.241	**.440**	Age
"An e-learning tutorial should…the practical examples and exercises should be reviewed during class"	.058	.174	**.420**	class_Review
Was it easy to dedicate some time in order to complete the e-learning module before class?	.208	.331	**-.410**	time_Easiness

Extraction Method: Principal Axis Factoring.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 6 iterations.

Bold values above the criterion level of 0.4.

Although the purposive samples are small to medium in the context of an exploratory research, the reliability of our scale was checked in order to understand how much the measure consistently reflects the constructs that it is measuring (see Table 21, Table 22 and Table 23).

Factor 1

Looking at subscale Factor 1, the overall reliability is .685. Even if this value is lower than 0.7, this level is considered acceptable given the exploratory nature of the research. The values in column *Corrected Item-Total Correlation* are all above .3, which means that all items correlate relatively well with the total. None of the items would increase the reliability if they were deleted because all values in *Cronbach's Alpha if Item Deleted* are less than the overall reliability of .685.

Table 21. Reliability of the scale (Factor1)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.685	.705	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Are you satisfied with the e-learning tutorial ?	12.264	7.223	.597	.425	.577
How much did you learn from the e-learning tutorial ?	12.236	7.483	.510	.375	.610
"The module in geostatistics ...makes me confident to participate in class"	12.400	7.584	.433	.255	.639
"An e-learning tutorial should...the completion of the module should count for my grade"	13.214	6.859	.357	.172	.690
"The module in geostatistics ...is exhaustive, with all the same detailed explanations as in books"	13.371	7.635	.374	.160	.664

Factor 2

Considering subscale Factor 2, the overall reliability is .574 which is below .7. However, in the context of the study, this level is considered acceptable. The values in the column *Corrected Item-Total Correlation* are all above .3, which means that all items correlate relatively well with the total. In the case of future usage of the questionnaire, the last item on self-assessment capabilities would increase the reliability if it were deleted (*Cronbach's Alpha if Item Deleted* > .574).

Table 22. Reliability of the scale (Factor2)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.574	.601	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
"An e-learning tutorial should…create interaction with the data, with the key concepts"	8.77	1.385	.499	.291	.288
"An e-learning tutorial should…explain the main concepts and their relationships"	8.51	1.924	.387	.227	.501
"An e-learning tutorial should…include exercises with feedback for self-assessment (quizz)"	8.93	1.324	.320	.117	.626

Factor 3

Finally, subscale Factor 3 has an overall reliability of .581, which is below .7. However, in the context of the study, this level is considered acceptable. The values in column *Corrected Item-Total Correlation* are all above .3, which means that all items correlate relatively well with the total. None of the items would increase the reliability if they were deleted because all values in *Cronbach's Alpha if Item Deleted* are less than the overall reliability of .581.

Table 23. Reliability of the scale (Factor3)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.581	.590	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
"An e-learning tutorial should…provide a printable file for future inquiries"	7.62	3.195	.453	.210	.392
How much time / scale	8.09	2.828	.358	.135	.549
"An e-learning tutorial should…the practical examples and exercises should be reviewed during class"	7.71	3.464	.374	.159	.505

The items that cluster on the same factor suggest that Factor 1 represents "learning perception", Factor 2 represents "expectations towards e-learning", and Factor 3 represents the "persistence over time" and call for class review.

In order to build a path model related to Factor 1, the cluster of variables leading to Factor 1 were used and added the "perceived usefulness" discussed previously. The resulting model is represented in Figure 34 and the results indicate that the hypothesized model adequately represents the data: CMIN/DF = 1.53, CFI = 0.914, TLI = 0.798, RMSEA = 0.083 90% CI [.0, .246], PCLOSE = 0.240.

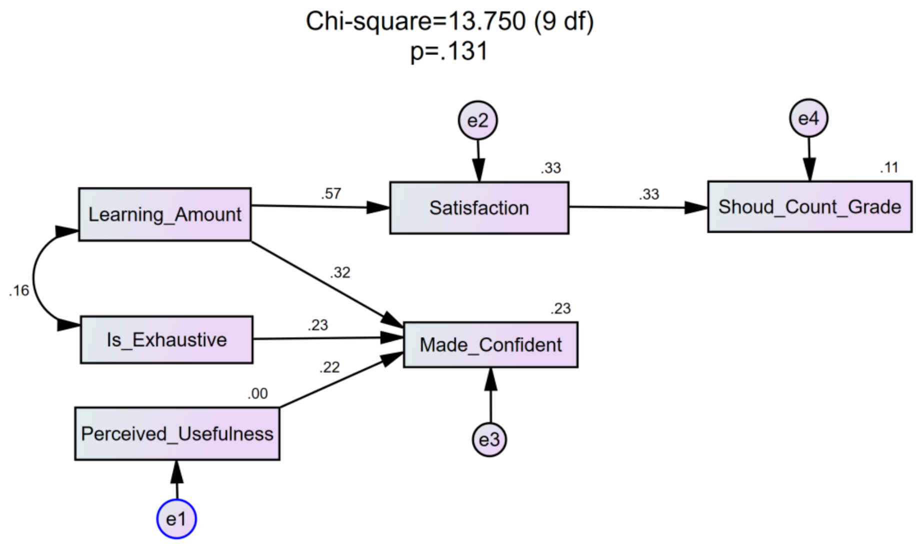


Figure 34. *Model of the relations between the observed variables linked to the subscale construct relative to Factor1.*

This model, which is a good fit of the data set, demonstrates that the level of satisfaction is related to the amount of learning perceived by the learner. The confidence level to participate in class is, in turn, related to the amount of learning perceived by the learner, the comprehensiveness of the e-learning module, and the “perceived usefulness” of what is been taught. The concern to count the quizz results for grading is also related to these predictors. The model of the relations between the observed variables linked to the subscale construct relative to Factor 1, built from the set of data, enables advancing some possible understanding of the many opinions users have on their learning experiences and also on the e-learning module itself. The system of relationship helps to explain why the e-learning approach is in tension with other considerations from which the learners evaluate their learning experience and especially the exhaustiveness of the resources. In addition, whereas students have a higher satisfaction level, no significant difference has been observed between university and industry on the construct “learning perception”. This could be explained by the fact that employees have a higher perceived usefulness level and are more oriented toward practice, hence compensating for their lower score on the satisfaction variable within that construct. To finish, the following question on the value of self-learning for a blended learning approach is left open. Is self-learning an attempt to learn as much as people can on the subject matter or to get people ready for later collaborative tasks during class? As far as can be judged, the second objective is in tension with learning a great amount of information, which in turn is a condition to learning satisfaction.

With respect to e-learning expectations, the latent variable is composed of the learners’ expectations to have conceptual explanations, interactive contents, and self-assessment. The need for explanations, related to subject-specific and cognitive learning, is no surprise for a self-learning tutorial. The other two items are related to multimedia learning. Multimedia application allows visualization and interactivity to illustrate the scientific concepts along with short loop feedback (Mayer, 2009, 2014).

A path model was also built relative to Factor 3. The resulting model is represented in Figure 35 and the results indicate that the hypothesized model adequately represents the data: CMIN/DF = 1.87, CFI = 0.75, TLI = 0.46, RMSEA = 0.107 90% CI [.0, .195], PCLOSE = 0.137.

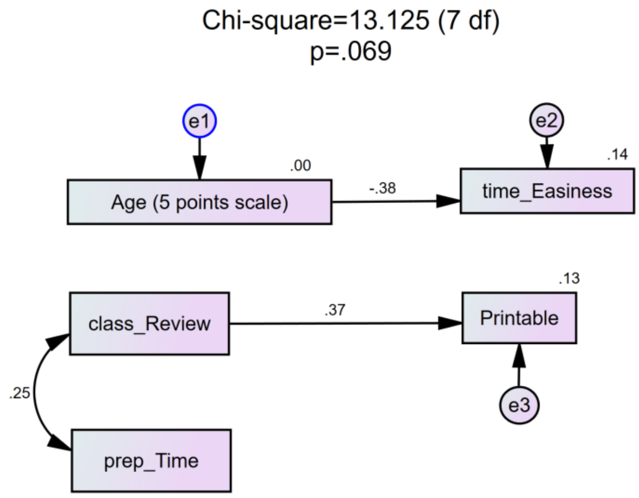


Figure 35. Model of the relations between the observed variables linked to the subscale construct relative to Factor3.

This model, which is a good fit of the data, shows that the level of easiness to find time for self-learning is related to age. Age has a negative relationship with the easiness to dedicate time to e-learning. This observation is consistent with the comment of the experienced instructor who stated professionals are too busy for e-learning. It is argued that professionals complain of their lack of time for multiple reasons. For instance, employees are probably busier in their extra professional life than students preventing them to complete e-learning out of work hours.

In addition, the three remaining items refer to dedication to self-learning for class preparation, the possible review of the exercises during class and the possibility to print a handout of the module. No causal relationship has been found between the easiness to find time and the dedication level to self-preparation. E-learning is being used by employees as much as by students. The arrangement of dedicated time for self-learning, even during training sessions, would probably increase even more the time spent on e-learning. The underlying explanation could be found in the "readiness-to-learn" principle of adult learning theories. According to

Knowles, Holton, and Swanson (2012) “adults become ready to learn those things they need to know and be able to do in order to cope effectively with their real-life situations” (p. 67).

Below, Figure 36 shows the general model built from the EFA analysis. The results indicate that the hypothesized model reasonably represents the data: CMIN/DF = 1.37, CFI = 0.84, TLI = 0.762, RMSEA = 0.069 90% CI [.0, .11], PCLOSE = 0.227.

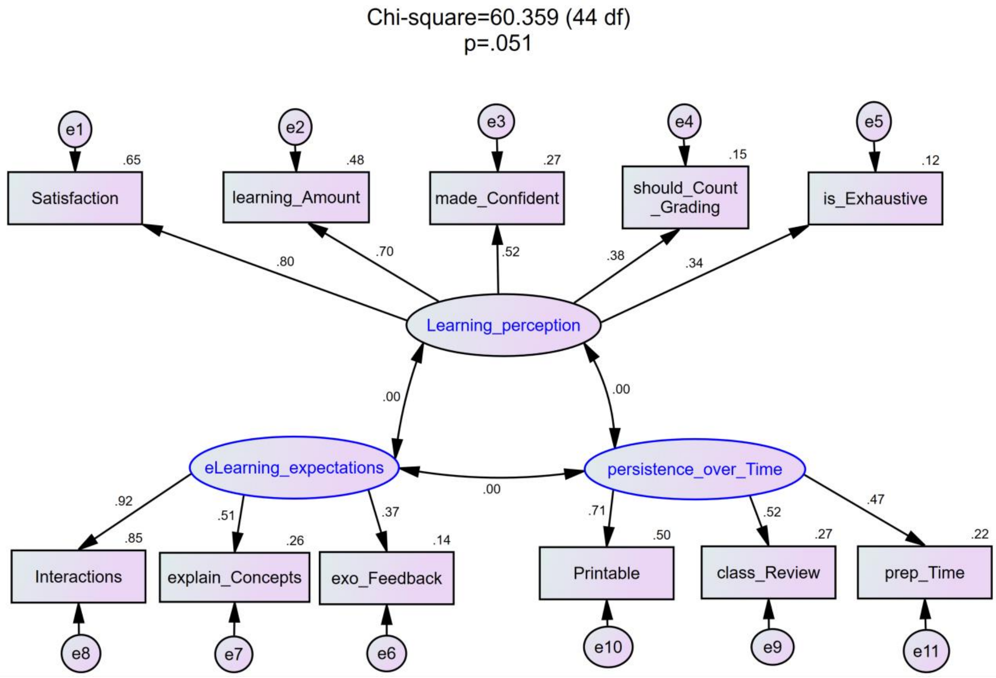


Figure 36. General model of the items clustering on the three latent variables

All the regression weights of the previous path diagrams are given in Appendix 30.

With this general model in mind, the possibility to explain some complex relationship between variables can now be contemplated.

In order to better understand the differences between university and business, some additional comparison tests were carried out between the means of factor scores for the two populations (see Table 24). These results show that there is no significant difference between universities and businesses considering the perception of learning, nor the expectations about e-learning. However, employees rank high in the third construct called “persistence over time” which is related to time and dedication to learning (Figure 37). This construct includes the ability to print the module content. This request means that future use of the material is expected. Indeed, the instructor in Company A reported that some learners arrived in class with the handout of the module and some annotations on it. In addition, this latent variable includes the request to review the exercises in class, which validates the practice put into place in company A, where the instructor took the decision to review the exercises in class, addressing the expectations of the learners. Time dedication to learning (expected preparation time) was also found in this construct. This variable is a marker of learning desire.

Table 24. Comparison tests between University (U) and Business (B) on factor scores

	U	B	Mann-Whitney test		Kolmogorov-Smirnoff		t-test	
Factor1	M = 0.17	M = -0.32	U = 272 z = -1.938 p = .053 r = -.24	Not significant	D(64) = 0.103 p = .087	did not deviate significantly from normal	t(62) = 1.717 p = 0.091	Not significant
Factor2	M = 0.16	M = -0.25	U = 289 z = -1.68 p = .093 r = -.21		D(64) = 0.171 p < .001	deviate significantly from normal		
Factor3	M = -0.32	M = 0.7	U = 630 z = 3.5 p = .000 r = -.44	Significant, medium-large effect size	D(64) = 0.069 p = .200	did not deviate significantly from normal	t(62) = -4.09 p < 0.001	Significant, medium-large effect size (r = 0.46 and d = 1.14)

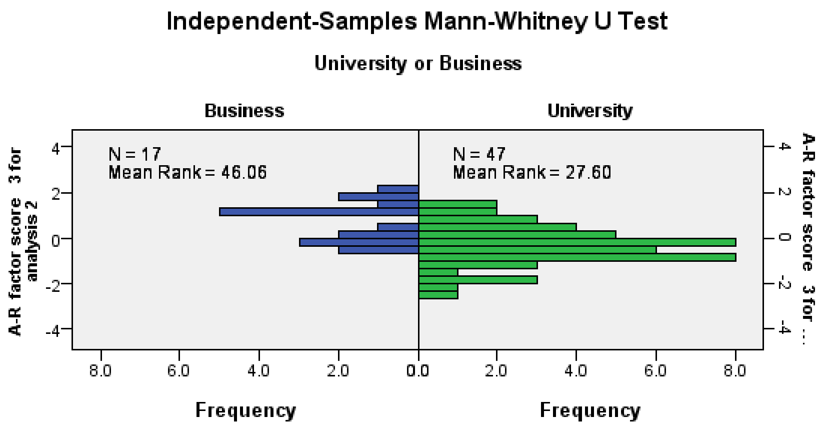


Figure 37. Independent-Samples Mann-Whitney U Test on Factor 3.

From the learners' perspective, the following observations and results can be advanced with regards to the research questions.

First, considering the e-learning usage for Blended Learning, the resource has been used by 84% of the learners with a duration of 69 min on average. This duration is higher than the estimated time of usage the module was designed for and higher than the time learners are ready to dedicate on average. Students use the e-learning during evening and week-end (93%) and at home (78%). Employees use the e-learning during work hours (59%) and at the workplace (68%). Employees seem to dedicate more time on exercises and less time on quizz than the students (evidence from small sample size). The results of the quiz are similar.

Employees seem to underperform at question Q1_4 and Q1_7 and over perform at question Q2_4.

Second, the following factors influence the application of a common learning resource within academia and industry. The difference of age between students and learner may impact the usage. It has been reported that employees were less comfortable with Excel™ functions for instance. Furthermore, students do not perceive the direct application of what they learn as much as employees in their daily activities. Fifty-seven percent of students can estimate future usage and 68% of employees can estimate future usage of what they learn. However, it is fair to say that the rate is still high for students. This could be explained by the fact that students engaged in a specialized master related to the field of Geology. Moreover, employees claim it is not easy to dedicate time to self-learning. However, no relation has been established with the dedication level to self-preparation, the module usage time, which is slightly higher than students' one, nor the global satisfaction (independent variables). At university, the class is larger than in companies, where the class is small and well adapted for individual follow-up.

Finally, considering the design of common LR, students are younger than employees and could be subject to less anchoring. However, in the context of the study, an introductory class is given which would lower the anchoring effect (new material for all). Preparation for self-study is estimated to be 46 minutes for students and employees. No tolerance for repeated material has been highlighted in the verbatim. In particular, employees have very low tolerance to duplicated activities. Satisfaction is a consequence of the perception to having learnt something. The more the learners think they have learnt, the more satisfied they are. It has been found that the capacity to make students ready (confident) for class preparation is a consequence of the perception of learning, the exhaustiveness of the module and the perceived usefulness of what is being learnt. Business calls for class review. There is a relationship between the self-preparation duration and the desire to review the exercises during class. The need for class review is a signal of commitment to learning. In coherence with the theory, no UB difference is found with respect to e-learning expectations.

3.2. The Design of an Instructional Model for Blended Learning in Academia and Industry

This section aims to set the basis for an approach to evaluate the instructional settings of blended learning and share learning resources between University and Business. The first part organizes the research results against the main contextual factors. The second part proposes an Instructional Model for UBC in EE.

3.2.1. Contextual and Individual Factors

The previous section identified the main results considering the usage, application and design of common learning resources within academia and industry. This section will map all the identified elements of the research results which create expectations, influence the usage (learning experience), and contribute to greater satisfaction. Those categories correspond to what is called herein an Expectation / Usage / Satisfaction (EUS) cycle where the leaners first have expectations about a specific training, then they follow the instructional activities and finally evaluate instruction. Before analyzing the factors at the learner's level, first the institutional contexts of academia and industry were taken into consideration.

Table 25. The EUS cycle for the institutional contexts of U and B.

	Expectations	**Usage**	**Satisfaction**
University	➢ Be recognized (rankings): competition ➢ Research activities, dissemination of knowledge (competition for IP) ➢ Student employment ➢ Control expenses ➢ Political force to lower skill gaps ➢ Develop skilled faculty for UBC ➢ Teachers are trained to ID but do not use any particular framework	➢ Different blended teaching strategy depending on the teacher ➢ The desire to apply e-learning depends on the age of the teacher ➢ Big groups (26)	➢ See verbatim "instructors" + interviews
Business	➢ Performance, competitive ➢ Authentic, real challenges ➢ Optimize learning delivery ➢ Employer brand ➢ Lower time-to-competency ➢ Instructors are not trained to ID	➢ Different blended teaching strategy depending on the teacher ➢ The desire to apply e-learning depends on the age of the teacher ➢ Small groups (6) ➢ No reporting of the learners' performance (RH) ➢ The LMS could prevent Excel™ to open (corporate security settings)	➢ See verbatim "instructors" + interviews

According to Table 25, considering the university context, the main driving expectations for UBC is the necessity for universities to disseminate research knowledge, provide students guidance for employment, control ID expenses, develop skilled faculties for UBC and develop instructional frameworks for the design of LR in EE. On the other hand, companies face real life challenges which are useful to develop engineering minds, they are willing to deliver effective training programs and lower time-to-competency. There is an unbalanced set of interests for UBC between U and B in EE leading eventually to a drop of the professional participation, as observed in France with the IUTs for instance (Delahousse & Bomke, 2015). Similarly to academia, trainers in the industry do not use any particular ID methodology and would be interested in developing instructional frameworks for guiding the design of shared learning resources. Regarding teaching experience, both teachers and instructors have the autonomy to design their course program and the most experienced instructors are less inclined to apply e-learning in their course. The size of the class is smaller in companies and no reporting of the learners' abilities is reported to Human Resources or the Managers for instance.

Table 26. The EUS cycle for the learners in U and B.

	Expectations	**Usage**	**Satisfaction**
Students	➢ Being hired ➢ Get a diploma (didactical contract) ➢ Learn what, why, how ➢ Do not expect direct application of what is learnt ➢ Cannot estimate future usage (43%) ➢ Factor 2	➢ 84% dedicate time for self-learning (69min), 46min preparation time ➢ 91% dedicates time to quizz ➢ 93% evening or WE, 78% home ➢ Younger (less anchoring)	➢ Duration, conciseness, ease of usage (Excel), real-time feedback and scaffolding (exercises) ➢ More satisfied, learnt more than employees but rank the same for the construct "learning perception" ➢ Factor 1 ➢ See verbatim
Employees	➢ Professional well-being (working contract) ➢ Better achievement ➢ Learn, what, why, how ➢ Need to be informed on the course structure (blended) ➢ Cannot estimate future usage (32%)	➢ 84% dedicate time for self-learning (69min), 46min preparation time ➢ dedicate time for exercises and practice ➢ perform worth Q1_4, Q1_7, better Q2_4 ➢ 59% work hours, 68% workplace ➢ Technology (Excel) could be more difficult to use (age) ➢ Not easy to find time (complain)	➢ Avoid redundancy with class ➢ Lower than students but rank the same for the construct "learning perception" ➢ Factor 1 ➢ See verbatim

According to Table 26, university students are committed to respect a didactical contract where the institution and the teachers have a moral authority for the provision of education. Both the teacher and the student expect something from each other. Within this contract, students are not expected to directly apply what they learn in a professional reference frame, although the masters programs under consideration aim to develop young professionals ready to enter the job market. On the other hand, employees are tied to a working contract, the aim of which is to develop professional skills and reach a higher professional performance within a corporate context. Employees are oriented towards practice. Considering the learning experience, self-learning is rather achieved at home for students and at work for employees. In this respect, it should be highlighted that although employees complain about low time availability, they dedicate as much time to course preparation as students. These observations suggest that specific scheduled time for self-learning during working hours would eventually allow even higher dedication to self-preparation.

As previously discussed, students' global satisfaction is higher than that of employees. When considering the construct relative to "learning perception", which includes confidence to go to class, no significant difference has been observed.

Table 27. The EUS cycle considering the teachers' values and believes.

	Expectations	Usage	Satisfaction
Values / believes	DESIGN: ➢ Teachers think they have the necessary relationship with UB ➢ Teachers do not think there is a cultural division between UB ➢ Teachers think industry can bring authentic learning ➢ Teachers think UBC has multiple perspectives and enriches contents	IMPLEMENTATION ➢ Experienced instructors think professionals do not have time for self-learning	EVALUATION ➢ What is the value of self-learning for blended learning?

Table 27 summarizes the observed values held by the teachers with respect to their expectations during the design of the LR, the learning experience which corresponds to the implementation of the module, and the satisfaction levels which were collected with the evaluation surveys. Teachers hold values and believes compatible with UBC in EE except experienced instructors who may believe professionals do not have time for self-learning. The results confirm that professionals claim they do not have time but as already explained, it does not prevent them from being satisfied and dedicating time to self-learning, and as much as students.

Now that we described the research results following the EUS cycle for both learning populations, we propose to organize the instructional components with the aim to later build a model of Blended Learning in Engineering Education.

3.2.2. A University-Business Model for Blended Learning in Engineering Education

The aim of this section is to describe a model for Blended Learning between University and Business in EE. The UB model for BL in EE is a simplified view of the potential for UBC in EE. It aims to help articulate sound ID methodology for BL in EE. Hereafter, the main components of BL in EE are organized and a description is provided for the UB model for BL in EE.

First, Table 28 organizes the main components of BL in the following categories:

- The learning strategy and method
- The learning objective, the activity and its granularity
- The cognitive process, the nature of knowledge and evaluation
- The contributors among U and B and the situational factors.

“Contextualization”, as defined in Table 28, is a situation where the learner needs to frame a problem in order to activate generative cognitive processing. “Contextualization” is not an activity by itself but rather characterizes the transition to the application of knowledge. In the e-learning module in Geostatistics, “contextualization” is embedded in the many exercises except from industry data set. The activities designed for “contextualization” would be designed by University and Business people together. These activities aim at developing the learners’ capability to deal with challenging situations and their definition depend on:

- The readiness of the learner: cognitive capacity, prior knowledge, affective aspects;
- The didactic aspects (content/discipline): level, complexity, extraneous load;
- The context: university (liberal, research, service), business context and requirements, physical aspects (facilities, software…).

Table 28. Instructional Components for Blended Learning in EE.

Strategy	Self-learning		Social & collaborative practice
Method	Self-paced, **CBT***, tutorial, book, inquiry		**Classroom***, social partnership, CoP/CoI, internships, Project Based Learning, virtual teams, Business cases/game/simulation
Objective	Cognitive learning (pre-training) Dissemination of knowledge	Social practice (Situated learning / Learning in context) Application of Knowledge	
Activity	Instructional message (theory) Science Concepts: mental models, knowledge structure	Problem framing Metacognition / holistic view Embedded mind Social practices of reference (Martinand) Social / physical awareness Formulating realistic problem	Application and production Engineering (authentic) Design, workflow System thinking Human judgment, decision-making Social practice / physical activity Solving realistic problems Behavior (participation)
Granularity	Compartmentalization, fragmentation		Holistic design
Cognitive processing	Essential: Information Factoids Inert knowledge Rote learning	Generative: Meaningful learning (integrated knowledge) Organizing coherent structures with prior knowledge Motivated to make sense of the material and to reach a larger goal	Collaborative and human based (project based, team based) Social partnership Conversation, challenges Affective, adaptive, interactive, creative
Nature of Knowledge	Facts, concepts	Awareness Objective setting Attuned to constraints Selection of relevant info	Procedures, strategies (metacognition)
Evaluation	Retention: information, knowledge	Understanding a context	Transfer: capability, achievement participation
Contributor	University	**CONTEXTUALIZATION (UBC)**	Business
Situational factor	Place of research and knowledge creation (universal view)		Place of knowledge utilization (utilitarian view)

* Learning methods considered in the research

A special care should be paid to the people from university and businesses who participate in the design of the situational challenges. In accordance with the lessons learnt from the Lonely Wolf project and the study on European University Business Cooperation undertaken by Technopolis (Board, 2012), bridging the cultural division between academia and industry requires strong university leadership, faculties that understand business and the nature of knowledge creation and circulation in the industry, as well as incentives and structures for academics to bridge that gap.

For effective “contextualization” to happen, the extraneous load has to be adapted to the learners’ cognitive abilities and prior knowledge. Advanced learners (with experience), who are self-driven and aware of their learning style, can deal with more complex situations and generative processing sooner. Their teaching should be of sufficient intellectual challenge to motivate them and even avoid the expertise reversal effect. As a consequence, the application of social and authentic challenges should be proposed earlier in their training in order to help them adjust and reorganize coherent structures with their prior knowledge.

The components of Table 28 respect the principle of non-redundancy of the instructional message. Indeed, the social environment (classroom part) does not include any theoretical learning which is tackled on an individual basis (self-learning). As a consequence, the model is coherent with current practices such as the flipped instruction where students learn on a self-paced basis and where practice is performed in a collective context.

Although Blended Learning refers to a mix of various event-based activities as online learning, self-paced learning, synchronous and asynchronous activities, the definition does not specify the characteristics of the activities taken into account in order to qualify in which way they are different. According to the findings, and from a learner-centric view, the main difference comes from the capability to study on a self-basis (one human using non-human learning resources) or with the contribution of a group of people (synchronous or asynchronous). Consequently, in the case of this research, Blended Learning could be characterized as an instructional system which combines self-learning, with the e-tutorial in Geostatistics, and collective learning within class.

Two different kinds of knowledge are selected in order to make the distinction between self-learning and collective learning: declarative knowledge and tacit knowledge. We argue that self-based learning relies extensively on knowledge which has been made explicit by other people (declarative knowledge and formal instruction). On its part, collective learning taps on multiple-sources of informal knowledge that would take a long time to formalize (tacit, distributed and informal knowledge), either because too many people are involved and have a piece of knowledge; or because deep understanding of complex systems is not easy to define and describe; or because the variability of practice on specific and complex tasks would be more difficult to describe than experiment (like the use of a professional software for instance). According to Wenger et al. (2002), “from a business standpoint, the tacit aspects of knowledge are often the most valuable. They consist of embodied expertise – a deep understanding of complex, interdependent systems that enables dynamic responses to context-specific problems” (p. 9).

Figure 38 is a chronologic representation of learning based on the distinction between declarative and tacit knowledge.

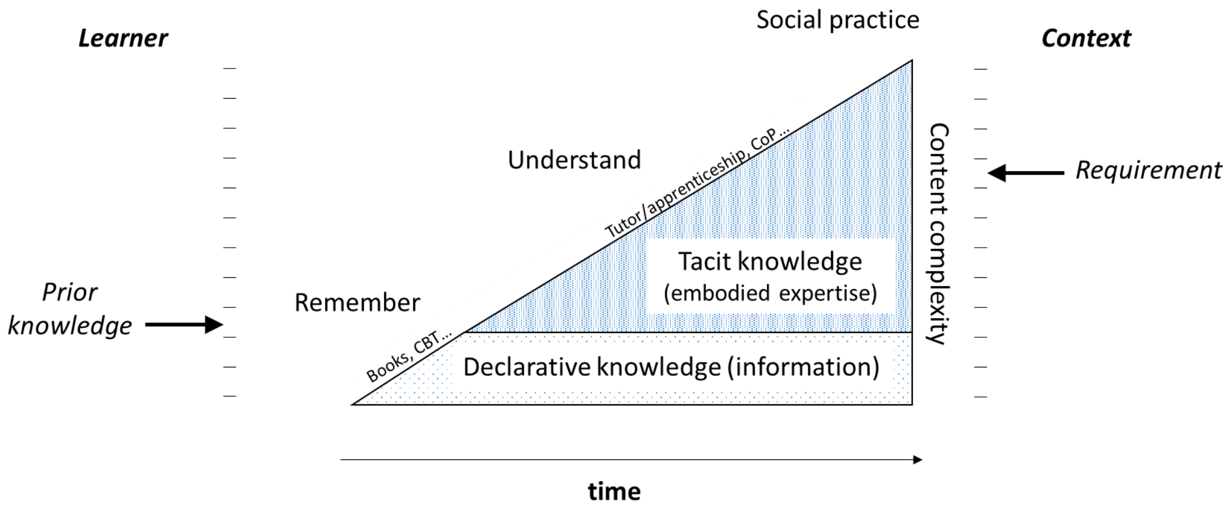


Figure 38. Chronologic view of Blended Learning in Engineering Education (learner centric).

In the context of this research, the course was composed of an interactive module for self-learning and a class with a group of people learning and training with a professional software, necessary for social practice to occur (in a professional context). In this representation, the learners' previous knowledge was low but not null. Indeed, people previously knew about the basics in algebra, mathematics, and even in statistics. The contextual requirements level represent the expectations drawn on one's training by the institutional authority. At university, students had to know about the basic principles of statistics to pass later exams, and in companies, employees were eager to apply their knowledge in their daily projects.

With this view in mind, optimizing time-to-competency would consist in adopting the best mix of instructional events in order to maximize the slope of the learning curve to its highest potential. In the context of the study, the self-learning modules allowed to effectively deliver the pre-requisite information and theory (pre-training), put theory in the perspective of its application in the particular oil and gas sector with the use of applied exercises made of industry-specific dataset ("contextualization") and class allowed a group of people to create value by exchanging tacit knowledge and to practice with the professional software (social practice).

Figure 39 represents two different University-Business systems. The first one is a system where university and business are seen as independent systems and the second one corresponds to the research study where both university and industry are overlapping.

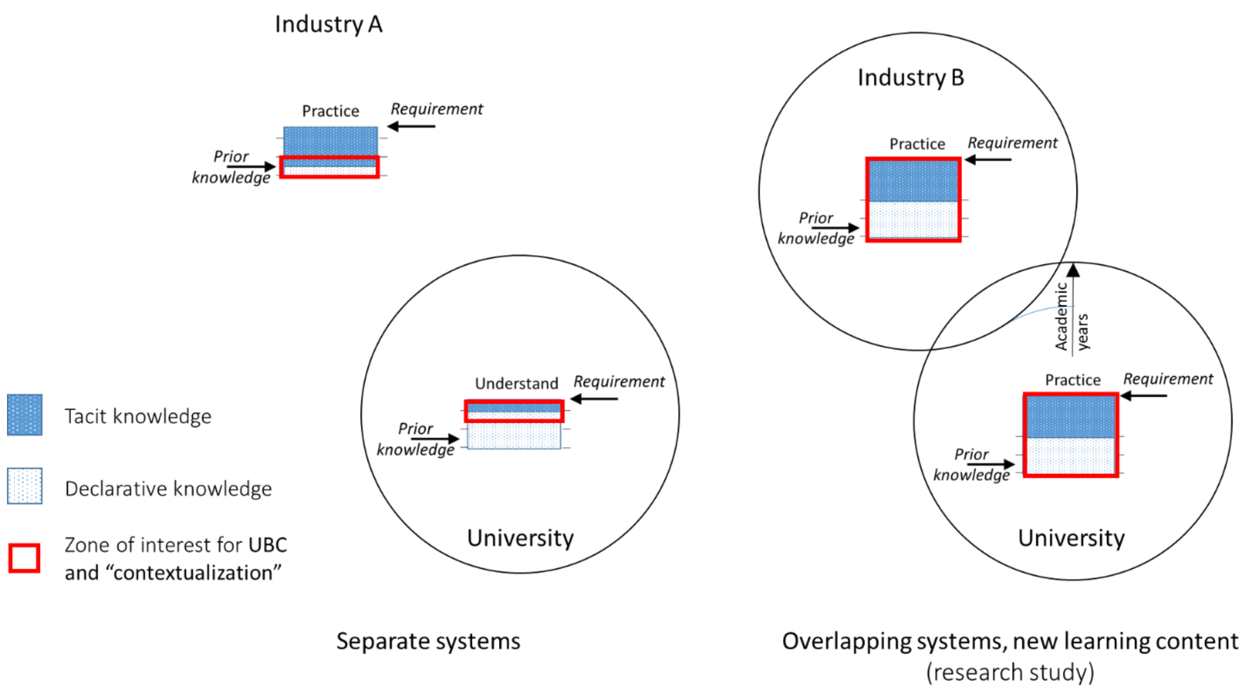


Figure 39. University-Business Model for Blended Learning in Engineering Education.

Interestingly, the model does not include a description of any particular multimedia principles for UBC. Accordingly to what has been said previously, the right application of technology (right design, right functioning) is a necessary condition but not sufficient to guarantee effective learning in university and business. In the case of Multimedia Learning, the existing theory of Mayer (2009) describes accurate and relevant principles for the design of digital resources (presentation-modes view).

This model goes further than pure technical preoccupations and suggests the ID has to be done collaboratively between U and B. A recurrent question, symbolized by the LO paradox, is how instructional designers can include contextual information in a LR which is predisposed for shared usage within different contexts. The UB model for BL in EE introduces the concept of the zone of interest for UBC and "contextualization" which corresponds to the potential to design common LR between academia and industry. It is composed of the portion of declarative and tacit knowledge necessary for learning to occur. In the separate system, university provides general education for students who will later enter into diverse industries. The zone of interest for UBC for common instruction is small because no particular knowledge in the specific discipline related to Industry A is delivered. However, for an introductory class on a special practice, as was the case in this research study, the UBC zone of interest is larger and covers both theory and practice. First, the university and corporate populations started from equivalent prior knowledge levels; and second, they both had interest and contextual requirements to master social practices related to Geostatistics. As way of example, the participating students were following a Master of Science in Geosciences and had an interest in developing their theoretical and practical knowledge in Geostatistics for future career perspectives.

The typology of "contextualization" depends on the UB relationship against a particular discipline (also called Social Practice) and should also include other individual, didactic and contextual factors. On top of the availability of people with the right abilities to manage UBC, as far as can be judged, on the long run, the main hurdle is the unbalanced set of U and B interests. As way of example, whereas teachers consider that industry can bring authentic material, teachers do not consider to know more than industry on teaching and knowledge assessment. Consequently, the interest of the industry for specific research based knowledge should be sought, more likely to be mastered by faculty members, in order to make UBC sustainable.

It becomes clear that UBC for instruction is recommended in environments where students and professionals have the same need to learn declarative and tacit knowledge. It is the case when industry and university students have to learn research-based knowledge or when they need to develop social practices related to a particular industrial sector.

4. CONCLUSIONS AND PERSPECTIVES

This Design-Based Research aims at determining the main factors which influence the design and application of a common learning resource between academia and industry for Blended Learning in Engineering Education. In particular, three questions are addressed:

1) Is the same learning resource used differently within academia and industry for blended learning?

2) What factors influence the application of a common LR within academia and industry?

3) What are the main factors to be considered for the design and application of such learning resources?

First, considering the distinctive usage of e-learning between university and industry, it is of importance to recognize that the same e-tutorial has been successfully applied for BL in both contexts. Today, two companies and one HEI still use the resource for their teaching in Geostatistics. It is the illustration that multimedia learning theory, developed by Mayer (2009), describes principles which are relevant for effective learning to happen, with no distinction between students and professionals. In addition, it has been observed that professionals (called employees in the report) are ready to dedicate and do dedicate as much time to e-learning as students. Concerning the instructors, we observed creative ways of integrating the new learning activity in their course. The influence goes two ways. On the one hand, the course structure influences the way the e-learning tutorial is delivered. As way of example, a 3-day course program made it necessary to split the e-tutorial for its delivery in two times. The instructional delivery is polymorphic in the sense that a single learning resource can generate multiple chronological scenarios of usage. On the other hand, the introduction of a new learning activity (e-learning for self-learning) influences the class delivery. For instance, one teacher used the students' quizz results to start his course before reinforcing various concepts. Interestingly, screenshots of the module or the e-learning module itself were used during class, to illustrate some concepts with the interactive illustrations of the module, or simply to review exercises.

Second, some factors influence the application of common e-learning resources. One major aspect is the availability of the users to complete the module. Professionals claim they do not have time and some instructors think that professionals do not have time for self-learning online. However, employees do dedicate as much time to e-learning as students. As a consequence, the professionals' complaint should be interpreted as a call for more consideration in order to have more time, especially during their professional hour (when they complete e-learning activities) rather than a signal of low participation. In compliance with situated learning theory, employees are subject to the influence of their professional and individual contexts. In contrast with students who voluntarily dedicate most of their time to learning, employees have to reach their professional objectives defined in terms of working performance and often have busy personal life with social and family related commitments. Another prominent factor which influences the introduction of e-learning is the willingness of the instructors to use new instructional approaches. Considering both teachers and instructors, diverse levels of interest to apply e-learning to one's course have been observed. It has been measured that more senior instructors generally do not plan to use e-learning in their courses. Interestingly, they argued that professionals don't have time for e-learning…

Third, at the time to design instructional programs which include common learning resources for academia and industry, instructional designers should take into account some additional aspects. Despite a lack of time, subject to complaint, professionals not only complete the self-learning activities as much as students but even call for collective review during class. One observation has been their tendency to print the e-tutorial handout and make annotations on it before going to class. According to the EFA and the three-factor model of learners' attitude towards e-learning, the main significant difference found between students and professionals is employees' expectation for an integrated and global approach between the learning activities, with the aim of reviewing the exercises, and to practice. This finding complies with the principles of adult learning described by Knowles et al. (2012), which highlight the necessity for adults to apply knowledge in the context of real-life situations.

To finish, we measured a positive relationship between learners' satisfaction and the need for exhaustive material. However, if considering that the primary purpose of learning prior to class is not to deliver exhaustive and complete information on a subject-matter but rather to prepare students to attend collective activities, special care is hence recommended not to consider only the learners' global satisfaction in order to evaluate the effectiveness of the self-learning activity. As way of example, students are significantly more satisfied with the e-learning. This leads to the question of whether the value of learning is the same for students and employees and of its alignment with the expectations drawn by the institutional authority. Since professionals are more interested in the practical application of knowledge, it is argued that self-learning, on its own, is less inclined to fully satisfy professionals' expectations.

Interestingly, it was found that teachers and instructors do not follow any particular Instructional Design methodology. As a consequence, the development of a model set the basis to establish an ID framework for the development of University Business ID principles. As a result, the direct collaboration of faculty members with corporate instructors would allow knowledge circulation between research and industry, between initial and continuing education, and students would benefit from advanced scientific and technical knowledge connected to real industry challenges. It would also allow to develop a collaborative culture and a cross cultural understanding as the contributors from university and business would learn to work together. Hence such design principles would help to develop cost effective solutions with shared investments for the development of e-learning solutions; make knowledge circulation happen between academia, research and industry with research knowledge dissemination, vocational learning in STEM and lower time-to-competency; and develop professionals with the special abilities to manage cross-organizational activities for successful UBC management.

From the research results, a model for BL in EE (see Figure 39) was built which includes individual, contextual and information-related factors. Information has been shared in declarative and tacit knowledge which is considered to be the separation between what can be learnt on a self-paced basis and what is learnt in a collaborative environment. This model is useful to make a judgement on the potential for UBC in education and training. UBC is deemed necessary to design what are called herein situations of "contextualization" where the learner is challenged and needs to frame a problem. As mentioned above, the interest zone for UBC depends on the UB relationship against a particular social practice. UBC for instruction is recommended in environments where students and professionals have the same need to learn new knowledge. This is the case when industry and university students have to learn research-based knowledge or to develop social practices related to a particular industrial sector. Considering the research, the learners developed their abilities to model hydrocarbon reservoir with geostatistical tools. This practice involves the use of professional software. UBC for ID is successful in this field for two major reasons related to "contextualization". First, the users need to understand the theoretical concepts in Geostatistics in order to frame their objectives and develop the relevant workflows, and second, the science is modern (created in the 1950s) and continuously benefits from software and calculation improvement in order to support advanced simulation methods. As a consequence, the social practice is influenced by the most recent tools development.

In addition to "contextualization", the opportunity for UBC also comes from the interest to make learning in science and engineering attractive. Interestingly, no obstacle for UBC in ID has been found, however, we argue that UBC is not part of the institutional priorities in training.

For future research on UBC in EE, we consider studying the relation between the nature of knowledge (tacit/declarative, formal/informal) and the instructional systems in academia and industry. Indeed, this research opens new questions on the impact of the nature of the information on the arrangement of instruction in universities and businesses. We propose to further analyze the circumstances, the forms, the advantages and disadvantages of making tacit knowledge become declarative in academia and industry.

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APPENDICES

Appendix 1. Characteristics of design-based research, adapted from Wang and Hannafin (2005).

Characteristics	Explanations	Advantages	Challenge / Limitations
Pragmatic	Design-based research refines both theory and practice.		Designers can adapt a mature theoretical framework or initiate a new one according to the purpose of the design and features of the setting
	The value of theory is appraised by the extent to which principles inform and improve practice.		
Grounded	Design is theory-driven and grounded in relevant research, theory and practice.	The resulting principles are perceived as having greater external validity tan those developed in laboratory settings and as better informing long-term and systemic issues in education	
	Design is conducted in real-world settings and the design process is embedded in, and studied through, design-based research.		Address simultaneously the multitude of variables evident in real-world settings (lack of controls and control groups, need for appropriate modeling of causality)
Interactive, iterative, and flexible	Designers are involved in the design processes and work together with participants.		Need to balance design and research roles to ensure that practical constraints are considered, alternative perspectives are provided, and discipline in the inquiry is ensured
	Processes are iterative cycle of analysis, design, implementation, and redesign.	Outcomes from previous loop provide explanatory frameworks and specify expectations that become the focus of investigation during the next cycle of inquiry	
	Initial plan is usually insufficiently detailed so that designers can make deliberate changes when necessary.		Should be flexibly adaptive but consistent with important principles of learning
Integrative	Mixed research methods are used to maximize the credibility of ongoing research.	By using a combination of methods, data from multiple sources increase the objectivity, validity, and applicability of the ongoing research	
	Methods vary during different phases as new needs and issues emerge and the focus of the research evolves.		
	Rigor is purposefully maintained and discipline applied appropriate to the development phase.		Compromise robustness of the theoretical anchors, the theoretical goals of the research, and the feasibility of the interventions (design)
Contextual	The research process, research findings, and changes from the initial plan are documented.		
	Research results are connected with the design process and the setting.		
	The content and depth of generated design principles varies.		The generalizability of findings increases when they are validated in successful design of more interventions in more contexts
	Guidance for applying generated principles is needed.		

Appendix 2. Pilot questionnaire for university learners.

Name (optional)

We used both e-learning and traditional learning at the same time.
Is it the first time you use blended learning ?

Yes ☐
No ☐

What is your global satisfaction level ?

Not satisfied ☐
Satisfied ☐
Very satisfied ☐

Why?

The module was 30mn duration overall. Its completion has been asked out of class. Is it :

Not justified, should be arranged during training time. ☐
Fair in comparison to the outcome. ☐
Other: ☐

Please rank from 1 to 10 each characteristic (1: the most important).
In addition, score the quality of each characteristic.

rank		low	average	good	very good
	graphic design quality				
	the interactive illustrations helped understanding				
	interactivity has been used when necessary				
	ease of use of each module				
	navigation system quality				
	clarity of the explanations				
	relevancy of the content in regards to the course				
	selection and numver of exercises				
	duration of each module				
	module integration to the course, learning sequences				

Do you agree with the following assertions :

	agree	disagree
the module helped to better understand the articulation of concepts in geostatistics (overview, meta description).		
the module helped to better understand the different concepts (variogram, kriging,...)		
the module saved time in favor of exercises, practice and interaction with the teacher in class		
the pdf will be useful for future inquiries		

Have you some recomendations ?

Appendix 3. Pilot questionnaire for learners from companies.

Name (optional)

Why did you register for the training in Geostatistics ?

Is this a new field for you (first class on that topic) ?

yes ☐
no ☐

We used both e-learning and traditional learning at the same time.
Is it your first blended learning for an internal training at Repsol ?

Yes ☐
No ☐

What is your global satisfaction level ?

Not satisfied ☐
Satisfied ☐
Very satisfied ☐

Why?

The two modules were 15mn duration each. Their completion has been asked out of class. Is it :

Not justified, should be arranged during training time. ☐
Fair in comparison to the outcome. ☐
Other:

Please rank from 1 to 10 each characteristic (1: the most important).
In addition, score the quality of each characteristic.

	#	low	average	good	very good
graphic design quality					
the interactive illustrations helped understanding					
interactivity has been used when necessary					
ease of use of each module					
navigation system quality					
clarity of the explanations					
relevancy of the content in regards to the course					
selection and numver of exercises					
duration of each module					
module integration to the course, learning sequences					

Do you agree with the following assertions :

	agree	disagree
the modules helped to better understand the course structure		
the modules helped to better understand the different concepts (variogram, kriging,...)		
the modules saved time in favor of exercises, practice and interaction with the teacher in class		
the pdf will be useful for future inquiries		

Have you some recomendations ?

Appendix 4. Codification of the pilot questionnaire for learners.

QL1	Name (optio2nal)
QL1.1c	Why did you register for the training in Geostatistics ?
QL1.2c	Is this a new field for you (first class on that topic) ? (Yes / No)
QL5c	We used both e-learning and traditional learning at the same time.
	Is it your first blended learning for an internal training at Repsol ? (Yes / No)
QL5u	We used both e-learning and traditional learning at the same time.
	Is it the first time you use blended learning ? (Yes / No)
QL2	QT2
QL3*	Why?
QL6c	The two modules were 15mn duration each. Their completion has been asked out of class. Is it (Not justified, should be arranged during training time / Fair in comparison to the expected outcome / other)
QL6u	QT6
QL6_text	comment
QL7_1…10	QT7_1…10
QL8_1…10	QT8_1…10
QL9_1c	Do you agree with the following assertions (agree / disagree)
	the modules helped to better understand the course structure
QL9_1u	QT9_1u
QL9_2	QT9_2
QL9_3	QT9_3
QL9_4	QT9_4
QL10*	QT10*

Appendix 5. Data collected with the questionnaires for learners (pilot phase).

		Learners @C	Learners @U
	N	7	72
	Nsurvey	7	7
	%	100%	10%
	N(PGS)		41
	Nsurvey		6
	%		15%
	N(RGE)		18
	Nsurvey		0
	%		0%
	N(RGE+RCM)		13
	Nsurvey		1
	%		8%
QL12c	Yes	4	
	No	3	
QT5, QL5c, QL5u	Yes	7	5
	No	0	2
QT2	not satisfied		1
	satisfied	1	6
	very satisfied	6	
QT4	For asynchronous learning (student self-learning)		
	also in class to illustrate some concepts		
QT6, QL6c, QL6u	not justified	1	
	fair	5	7
	no answer	1	
QT8	low		
	average		1
	good	3	6
	very good	4	
QT9	low		
	average		1
	good	2	5
	very good	5	1
QT10	low		
	average		1
	good	4	4
	very good	3	2

		Learners @C	Learners @U
QT11	low		
	average		2
	good	5	4
	very good	2	1
QT12	low	2	
	average	2	2
	good	1	5
	very good	2	
QT13	low		1
	average		2
	good	4	4
	very good	3	

QT14	low		
	average		1
	good	3	5
	very good	4	1
QT15	low		1
	average	1	3
	good	4	3
	very good	2	
QT16	low		
	average	2	2
	good	3	5
	very good	2	
QT17	low		
	average		2
	good	4	3
	very good	3	1
	Not answered		1
QT18, QT18c	agree	7	5
	disagree		2
QT19	agree	7	7
	disagree		
QT20	agree	7	4
	disagree		3
QT21	agree	7	7
	disagree		

Appendix 6. Verbatim given by the students to the open questions of the pilot questionnaire.

	Company	University
QL11c	Porque es una competencia que debo mejorar para maximizar mi desempeño en los proyectos en los que participo *(because it is a competence I need to improve in order to deliver my projects)*, because I need to understand the concepts of Geostatistics for my project, I would like to have basic knowledge of Geostatistics and practice examples, to learn how the maps are made and the petrophysical parameters are intagrated in the geological/geostatistical models, porque es la base téorica para poder desempeñar corectamente mi trabajo *(because it is the theoretical background to be able to deliver at work)*, for a better understanding of the several methods available and their application	
QT3 / QL3	El tipo de presentacion elearning suele tener una capacidad de sintesis de expresion grafica muy alta, lo que ayuda a la compresion de conceptos *(e-learning is illustrative and help to understand concepts)*, having an introduction to the topic before class is very useful, because for me it has been a very useful introduction to Geostatistics items, easy to understand, very enjoyable, this course gives a good overview on the methods applied in Geostatistics to create the models, me ha parecido un curso muy interesante donde se han cubierto todos los puntos clave para poder modelizar corectamente y con criterio los yacimientos geologicos *(the course is very interesting and covers all the aspects necessary to model correctly geological reservoirs)*, the information is very clear and focused	It was useful to have e-learning, THe course requires one to have a prior knowledge of what Geostatics involves, visuals where fine, but I couldn't understand the entire module - very little text available.
QT22	Con el tiempo, ir incluyendo mas material didactica *(include more educational resources over time)*, more practice examples, the e-learning should be also reviewed in the class as exercises to reinforce the concepts, it will be useful a test at the end of each module and more exercises. Some problems to login from Repsol Network	Clearer indications regarding the exercises A correction would be welcome, I checked the e-learning before the formal classes with the teacher. After the classes I will check it again and I'm sure I will take more advantage from blending both e-learning and formal classes, Explanations where very brief, and the progression to the exercise was very sudden - what to do with 'depth and 'continuous' column on exercise 1 was not explained. Personally, I would prefer a little more text that helps one grasp the ideas being presented very well. I perceived that a lot of attention was given to how concise the module was and the time it would take the student to complete it. However, if a student does not understand a concept and is willing to study to understand, a little more text which would help is welcome.

Appendix 7. Validation process of the main questionnaires for learners.

QUESTIONNAIRE FOR LEARNERS

Instruction

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	No		No	
3	No		No	
5	No		No	
6	No		No	
9	No		No	

Name

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	No		Yes	I would not ask for name at all. If you want to contact them klater than add that as an optional question at the end. Are you willing to participate i further research if so please enter name and contact details.
3	No		No	
5	No		No	
6	Yes	Again, if the questionnaire is not anonymous, add what you'll do with the name	No	
9	Yes	Me parece bien que sea opcional el nombre *(I also recommend anonymous surveys)*	No	

Gender

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	No		No	
3	No		No	
5	No		No	
6	No		No	
9	No		Yes	No creo que haya muchas diferencias por razón de género *(I don't think gender would influence a lot)*

Age

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	No		No	
3	No		No	
5	No		No	
6	No		No	
9	Yes	Puede resultar interesante para comprobar la aceptación en función de la edad. El uso de los sistemas de formación a distancia viene condicionado por la edad. *(it might be useful to check the acceptance against the age of the learners. The usage of distant learning solutions are related to the age)*	No	

First training

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	Yes	define training	No	
3	No		No	
5	No		No	
6	No		No	
9	No		Yes	Se pueden dispersar las respuestas. *(answers might be facultative)*

First blended?

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	Yes	the word presential is an uncommon word many people will not know what it means	No	
3	No		No	
5	No		No	
6	No		No	
9	Yes	Puede ser interesante este dato. No todo el mundo está de acuerdo con la formación a distancia. *(The data can be interesting. Not everyone agrees with distant learning)*	No	

Satisfaction

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	No		No	
3	No		No	
5	No		No	
6	No		No	
9	Yes	Prefiero opciones de respuesta pares. *(I prefer even numbers of possible answewrs)*	No	

Explain

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	No		No	
3	No		No	
5	No		No	
6	No		No	
9	Yes	Los comentarios abiertos aclaran más que una simple escala. Obligan a pensar. *(Open questions give more information than a simple scale. It forces to think)*	No	

How much did U learn?

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	Yes	answer should be nothing, somewhat and a lot maybe you also ask what they learned	No	
3	No		No	
5	No		No	
6	Yes	Hard to judge for a student. You can ask: did the e-learning prepare you well for classes and exams?	No	
9	Yes	Puede ser interesante. Las acciones a distancia causan desinterés en algunos alumnos ya habituados y pueden crear muchas expectativas en los nuevos. *(Can be interesting. Distant actions can lower learner's engagement when they are used of it, and raise expectations for the new ones)*	No	

Preparation to class

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	Yes	what do you mean by preparation?	No	
3	Yes	Do you mean the elearning module?	No	
5	No		No	
6	No		No	
9	Yes	Me parece necesaria esa introducción. *(I think this introduction is useful)*	No	

Methods comparison

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	Yes	Some of the learning methods could be part of e-learning	No	
2	Yes	I'd prefer a likert scale here	No	
3	No		No	
5	No		No	
6	Yes	Same comment: you might want to add 'as effective'	No	
9	Yes	Hay que pedirles que rellenen la última columna. *(They should be asked to fill the last column)*	No	

Duration

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		Yes	Depends on so many factors that I doubt there will be a general answer to this question
2	No		No	
3	No		No	
5	No		No	
6	No		No	
9	Yes	De nuevo estoy a favor de introducir la duración. *(Again, I would recommend to include the duration)*	No	

Easy o find time

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	No		No	
3	No		No	
5	No		No	
6	No		No	
9	Yes	Me aparece interesante que se añada el último apartado. *(I find it interesting to add the last paragraph)*	No	

Conditions

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	Yes	I would not use an open question here, but include possible answer to tick	No	
2	Yes	you may want to split in device type, connection type etc. We are having big problems with bandwidth issues, browser issues and they may cloud your research outcome	No	
3	No		No	
5	Yes	Use main options to simplify the study	No	
6	No		No	
9	No		Yes	No aporta mucho. *(Doesn't bring a lot)*

Expectations

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	No		No	
3	No		No	
5	No		No	
6	No		No	
9	Yes	Demasiadas cuestiones. ¿se podrían englobar? *(Too much questions, gather some of them)*	No	

Attributes

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	No		No	
3	No		No	
5	No		No	
6	Yes	should the table not be identical to 14?	No	
9	Yes	Es adecuado. Ayuda a reflexionar al alumno sobre lo que sabe. *(Adequate. Help the learner to think about what he/she knows)*	No	

Change to be made?

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	No		No	
3	No		No	
5	No		No	
6	No		No	
9	Yes	Es adecuado. Aunque podría haber algún apartado más, si el alumno lo detecta puede incluirlo en la parte abierta. *(Adequate. Although it could include some more paragraphs, if the learner wants he/she can add it in the open field)*	No	

Comments?

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	No		No	
3	No		No	
5	No		No	
6	No		No	
9	No		Yes	No tengo comentario *(I don't have comments)*

Response ID	Would you add some questions to guarantee the questionnaire's comprehensiveness -
1	
2	See my comment on how students watch it. There are three issues we found: internet connection Device Browser than can really screw up delivery.
3	Remy - again try this out on some real students as they always behave differently than you expect.
5	Sometimes use a not-centered scale (1-4, 1-6) to force students to have opinion
6	
9	Creo que no he podido aportar demasiado. *(I believe I didn't bring too much)*

Appendix 8. Questionnaire for students.

QUESTIONNAIRE FOR STUDENTS – E-LEARNING-

Instructions: this questionnaire measures your satisfaction level for the e-learning module in geostatistics. Your opinion matters. It will help us understand your needs for future enhancement and for research purpose.
Please write, circle or check your answer and give one copy to your teacher.
If you have any doubt or any comment on the questionnaire, please tell your teacher.

1. Are you : ◻ Male ◻ Female

2. What is your age ? ◻ < 23 ◻ 23-25 ◻ 26-29 ◻ 30-34 ◻ 35-39 ◻ 40-44 ◻ 45-49 ◻ 50-54 ◻ 55-59 ◻ >59

3. Is it your first training or first class in geostatistics ? ◻ Yes ◻ No

4. Is it the first time you combine both e-learning and classroom sessions in a single course? ◻ Yes ◻ No

5. Are you satisfied with the e-learning tutorial ?

not at all	a little	a fair amount	much	very much
1	2	3	4	5

6. Please, explain your answer above : ____

7. How much did you learn from the e-learning tutorial ?

nothing	not much	a little bit	quite a bit	a lot
1	2	3	4	5

8. What did you learn most from the e-learning module ? ____________________________________

9. How often will you use what you learnt from the entire course ?

   ◻ daily ◻ weekly ◻ monthly ◻ very few ◻ I don't know

10. How much time are you ready to dedicate for your preparation to one day of class (for instance with prior reading, e-learning…) ? _______minutes

11. Was it easy to dedicate some time in order to complete the e-learning module before class ?

very difficult	difficult	neither easy nor difficult	easy	very easy
1	2	3	4	5

Why ?__________________________

12. Where did you complete the e-learning tutorial ? ◻ at home ◻ at office ◻ other

13. When did you complete the e-learning tutorial ?

    ◻ work hours ◻ during class ◻ lunch time ◻ break time ◻ evening time ◻ week-end

Please, go to second page →

QUESTIONNAIRE FOR STUDENTS – E-LEARNING-

2/2

14. What do you expect from an e-learning module for class preparation ?

"An e-learning tutorial should…"

	strongly disagree	disagree	neutral	agree	strongly agree
1."…explain the main concepts and their relationships"	1	2	3	4	5
2."…open questions, problems that will be addressed in class"	1	2	3	4	5
3."…be short and concise"	1	2	3	4	5
4."…be exhaustive, with all the same detailed explanations as in books"	1	2	3	4	5
5."…make me confident to participate in class"	1	2	3	4	5
6."…use illustration, animation and interactivity only when necessary"	1	2	3	4	5
7."…create interaction with the data, with the key concepts"	1	2	3	4	5
8."…include examples from the industry, from the real world"	1	2	3	4	5
9."…include exercises with feedback for self-assessment (quizz)"	1	2	3	4	5
10."…the practical examples and exercises should be reviewed during class"	1	2	3	4	5
11."…the completion of the module should count for my grade"	1	2	3	4	5
12."…provide a printable file for future inquiries"	1	2	3	4	5

15. What attribute does the module in geostatistics possess ?

"The module in geostatistics …"

	strongly disagree	disagree	neutral	agree	strongly agree
1."…explains the main concepts and their relationships"	1	2	3	4	5
2."…opens questions, problems that will be addressed in class"	1	2	3	4	5
3."…is short and concise"	1	2	3	4	5
4."…is exhaustive, with all the same detailed explanations as in books"	1	2	3	4	5
5."…makes me confident to participate in class"	1	2	3	4	5
6."…uses illustration, animation and interactivity only when necessary"	1	2	3	4	5
7."…creates interaction with the data, with the key concepts"	1	2	3	4	5
8."…includes examples from the industry, from the real world"	1	2	3	4	5

16. Is there <u>one</u> section of the module you would have designed differently ?

Please choose only one of the following ☐ statistics ☐ variogram ☐ estimators ☐ simulators

What would you remove, improve or add ? ______________________________

____

17. Do you have any comments you would like to share with us concerning the questionnaire or the e-learning ?

____

18. Are your willing to participate in further research on e-learning ?

If so, please enter your name and contact details:

____

Appendix 9. Pilot questionnaire for instructors.

Name

What is your global satisfaction level ?

Not satisfied ☐
Satisfied ☐
Very satisfied ☐

Please, explain why (strengths, weaknesses...)

Do/will you use this module :

for asynchronous learning (student self-learning) ☐
also in class to illustrate some concepts ☐
other:

This module has been design for a blended learning (e-learning + traditional learning at the same time).
Is it your first blended learning application in teaching ?

Yes ☐
No ☐

The module is 30mn duration overall. Its completion is asked out of class hours.
Is it :

Not justified, should be arranged during training time. ☐
Fair in comparison to the expected outcome. ☐
Other:

Please rank from 1 to 10 each characteristic (1: the most important).
In addition, score the quality of each characteristic.

rank		low	average	good	very good
	graphic design quality				
	the interactive illustrations helped understanding				
	interactivity has been used when necessary				
	ease of use of each module				
	navigation system quality				
	clarity of the explanations				
	relevancy of the content in regards to the course				
	selection and numver of exercises				
	duration of each module				
	module integration to the course, learning sequences				

Do you agree with the following assertions :

	agree	disagree
the module helped to better understand the articulation of concepts in geostatistics (overview, meta description).		
the module helped to better understand the different concepts (variogram, kriging,...)		
the module saved time in favor of exercises, practice and interaction with the teacher in class		
the pdf will be useful for future inquiries		

Have you some recomendations ?

Appendix 10. Codification of the pilot questionnaire for teachers.

QT1	Name
QT2	What is your global satisfaction level ? (Not satisfied / Satisfied / Very satisfied)
QT3*	Please, explain why (strengths, weaknesses…)
QT4	Do/will you use this module (For asynchronous learning (student self-learning) / also in class to illustrate some concepts / other)
QT5	This module has been design for a blended learning (e-learning + traditional learning at the same time).
	Is it your first blended learning application in teaching ? (Yes / No)
QT6	The module is 30mn duration overall. Its completion is asked out of class hours. Is it : (Not justified, should be arranged during training time / Fair in comparison to the expected outcome / other)
QT7_1…10	Please rank from 1 to 10 each characteristic (1: the most important).
QT8_1	In addition, score the quality of each characteristic (low / average / good / very good)
	graphic design quality
QT8_2	the interactive illustrations helped understanding
QT8_3	interactivity has been used when necessary
QT8_4	ease of use of each module
QT8_5	navigation system quality
QT8_6	clarity of the explanations
QT8_7	relevancy of the content in regards to the course
QT8_8	selection and number of exercises
QT8_9	duration of each module
QT8_10	module integration to the course, learning sequences
QT9_1	Do you agree with the following assertions (agree / disagree)
	the module helped to better understand the articulation of concepts in Geostatistics (overview, meta description).
QT9_2	the module helped to better understand the different concepts (variogram, kriging,...)
QT9_3	the module saved time in favor of exercises, practice and interaction with the teacher in class
QT9_4	the pdf will be useful for future inquiries
QT10*	Do you have some recommendations ?

Appendix 11. Data collected with the questionnaires for teachers (pilot phase).

		Instructor @C	Former Teacher @U
QT5, QL5c, QL5u	Yes	1	
	No		1
QT2	not satisfied		
	satisfied	1	1
	very satisfied		
QT4	For asynchronous learning (student self-learning)	1	
	also in class to illustrate some concepts	1	1
QT6, QL6c, QL6u	not justified		1
	fair	1	
	no answer		
QT8	low		
	average		
	good	1	
	very good		1
QT9	low		
	average		
	good	1	
	very good		1
QT10	low		
	average		1
	good	1	
	very good		
QT11	low		
	average		
	good	1	1
	very good		
QT12	low		
	average		
	good		1
	very good	1	
QT13	low		1
	average		
	good	1	
	very good		
QT14	low		1
	average		
	good	1	
	very good		
QT15	low		1
	average		
	good	1	
	very good		
QT16	low		1
	average		
	good	1	
	very good		
QT17	low		
	average		1
	good	1	
	very good		
	Not answered		
QT18, QT18c	agree	1	1
	disagree		

QT19	agree	1	
	disagree		1
QT20	agree	1	
	disagree		1
QT21	agree	1	1
	disagree		

QT7	Instructor @C
graphic design quality	2
the interactive illustrations helped understanding	1
interactivity has been used when necessary	7
ease of use of each module	6
navigation system quality	8
clarity of the explanations	3
relevancy of the content in regards to the course	4
selection and number of exercises	9
duration of each module	5
module integration to the course, learning sequences	10

Appendix 12. Verbatim given by the teachers to the open questions of the pilot questionnaire.

	Instructor @C	Former Teacher @U
QT3 / QL3	Help to support the training during class From the instructor side, the e-learning module permits to organize and visualize the most important concepts the students must know, all in an interactive and visual manner. It is used as a support to the traditional training because the instructor can cover more topics during the session. E-learning inclusion in traditional training permits during class to: Open the discussion of concepts with the students Create curiosity about the topics that will be covered the next day Make them practice specific concepts that they must known.	strengths: interactivity, clear weaknesses: lack of many informations for each topic
QT22		more explanations, more exercises... but this is a very good starting point ! En résumé, je trouve le graphisme, et les pages très claires et bien faites. Par contre il manque beaucoup de choses à mon avis pour que cela puisse être considéré comme un cours de base en geostatistique (ou alors il faut une vraie explication en classe en parallèle). Par exemple, les caractéristiques d'un variogramme, range, sill, nugget, par exemple la variance et les poids de krigeage, par exemple les principes des méthodes de simulation, leurs paramètres, etc... *(To sum up, the illustrations and layout are very clear. However, we lack a lot to consider it to be a basic course in Geostatistics (or we need a real explaination in class in parallel). For example, variogram caracteristics such as the range, sill, nugget, variance and weights of the kriging, the principles of the smimulation methods, their parameters…)*

Appendix 13. Validation process of the main questionnaires for teachers.

QUESTIONNAIRE FOR TEACHERS

Instructions

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	No		No	
3	Yes	How do you send back one copy? To who? By when?	No	
5	No		No	
6	No		No	
9	No		No	

Name

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	No		Yes	I would not ask people their name. your response rate will drop.
3	Yes	Why do you need their name? How are you going to use their data? what assurances are you going to give re. confidentiality	No	
5	No		No	
6	Yes	Your questionnaire is not anonymous then. Add what you'll do with the name (will you contact them for instance?).	No	
9	Yes	El nombre de la persona entrevistada condiciona las respuestas. Creo que no debe aparecer este dato. *(the name of the person condition his/her answers. I don't think you should include it)*	No	

Questions prof geoscience

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	Yes	Q5: I would make a distinction between textbooks and reference books. and replace hardcopies with handouts or lecture notes	No	
3	Yes	Q1 & Q2. Years doesn't make sense - doesn't give you a feel for part-time / full time, significant / minor part of job?	Yes	Make the response area bigger other wise if people write in there it will be very crammed
5	No		No	
6	No		No	
9	Yes	Es una información demasiado completa. Algunos apartados pueden quedar vacíos. *(This information is too detailed. Several cells might be left empty)*	No	

Usefulness preparaton to class

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	Yes	not user what you mean by this question. I would not know what to answer	No	
3	Yes	What preparation are you referring to?	No	
5	No		No	
6	Yes	the text between (..) is unclear in relation to the question. Do you mean this as an example? Then add 'for instance for introducing new concepts' However, depending on your research question you might just delete the (..) text	No	
9	Yes	Siempre es necesario hacer una introducción antes de iniciar la clase. En e-learning también, aunque tengan las lecciones disponibles. *(It is always necessary to make an introduction before class start. The same for e-learning, although the lessons are available)*	No	

Comparison with other methods

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	Yes	all 'learning methods' can also be part of e-learning??	No	
2	Yes	I would use a likert scale yes/no is too black & white	No	
3	No		No	
5	No		No	
6	Yes	you can't choose 'as effective', which can very well be a legitimate answer.	No	
9	Yes	En la pregunta abierta que justifica las dos opciones anteriores podríamos encontrar más de una respuesta en blanco. *(In the open question which justifies the two prior options we could find more than one empty cells)*	No	

Duration

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		Yes	I don't believe there is a general answer to this question. It will depend on so many aspects, not the least the particular subject, the intended learning activities in the class, etc.
2	Yes	preparation by who? Teacher or student	No	
3	Yes	mn not a recognised abbreviation	No	
5	No		No	
6	No		No	
9	Yes	Esta información predispone al alumno para dedicarle más o menos tiempo. *(This information conditions the learner to dadicate more or less time)*	No	

Use for your course

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	No		No	
3	No		No	
5	No		No	
6	No		No	
9	Yes	Eliminaría el valor central o añadiría un valor más para no dar facilidades a los indecisos. *(Remove the central value or add an extra one to avoid easy choices for the indecise persons)*	No	

Explain

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	No		No	
3	No		No	
5	No		No	
6	No		No	
9	Yes	La ilustraciones favorecen la comprensión del contenido. *(Illustrations help to understand the content)*	No	

Will it help you?

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	No		No	
3	No		No	
5	No		No	
6	No		No	
9	Yes	Creo que aporta buena información. No añadiría nada más. *(I think it brings good information. I wouldn't add anything else)*	No	

Expectations

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	No		No	
3	No		No	
5	No		No	
6	No		No	
9	Yes	No se me ocurre ninguna cuestión más. *(I don't have more questions)*	No	

Attributes

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	No		No	
3	No		No	
5	No		No	
6	Yes	remove 'does' from 'The module in geostatistics does..."	No	
9	Yes	Parece conveniente, pero creo que esto habría que autorizarlo en cualquier materia. *(It seems relevant, but I think it should be authorized in any discipline)*	No	

Change to make

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	No		No	
3	No		No	
5	No		No	
6	No		No	
9	Yes	Creo que es suficiente. No me veo impartiendo esta materia. *(I think it's enough. I don't see myself delivering this course)*	No	

UBC

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	No		No	
3	No		No	
5	No		No	
6	No		No	
9	Yes	Creo que son demasiadas preguntas. Algunas se podrían incluir en otras. *(I think it is too much questions. Some could be gathered with others)*	No	

Comments?

Response ID	[Unclear]	- comment	[Irrelevant]	- comment
1	No		No	
2	No		No	
3	No		No	
5	No		No	
6	No		No	
9	Yes	En líneas generales me parece correcto. *(In general, it seems correct)*	No	

Would you add some questions to guarantee the questionnaire's comprehensiveness -

Response ID	
1	
2	Remy you need to test this on some real people. It seems very long to me so some people may lose patience. Think about how you are going to use the data that you get.
3	The questionnaire is clear. Its relevance depends on the study hypothesis but it looks complete
5	
6	
9	

Appendix 14. Questionnaire for instructors.

1/3

QUESTIONNAIRE FOR INSTRUCTORS – E-LEARNING-

Instructions: this questionnaire aims to understand your practices and attitudes towards e-learning. Your opinion matters. It will help us understand your needs for future enhancement and for research purpose.
Please write, circle or check your answer and send back one copy.
If you have any doubt or any comment on the questionnaire, please let us know at the end of the questionnaire.

1. If you teach or taught geostatistics or geosciences :

1.How many years of work practice do you have using geostatistics ?		
2.During that year(s), did you use geostatistics ?	□ daily □ weekly □ monthly □ other :	
3.How many years do you have as a teacher in geostatistics ?		
4.At which level of study are your students ? *Please choose all that apply*	□ bachelor degree (at university or at engineering school) □ master degree (at university or at engineering school) □ professionals □ other :	
5.What kind of course material do your students use ? *Please choose all that apply*	□ powerpoint □ word □ lecture notes □ textbooks □ reference books □ other :	
6.Do you share your own teaching resources with other teacher/instructor ?	□ Yes □ No	If yes, with who?
7.Do you use multimedia contents ? *Please choose all that apply*	□ video □ animations □ e-learning tutorials, courseware □ software □ simulators □ web □ other :	
8.What teaching method(s) do you mainly use in class ? *Please choose all that apply*	□ lecture □ practical work □ case studies □ project work in teams □ individual assignments □ one-to-one tutorials □ other :	
9.Did you receive training in instructional design, educational sciences…?	□ Yes □ No	
10.At your organization, do you have the support of some people to help you design your courses?	□ Yes □ No	
11.Do you follow a particular theory or methodology to design your course ? (socio-constructivism theory, adult learning, BLOOM taxonomy, ADDIE, 4C/ID…)	□ Yes □ No	If yes, which one(s) ?
12.Do you involve students when you design new course material ?	□ Yes □ No	Comments :

Please, go to next page →

QUESTIONNAIRE FOR INSTRUCTORS – E-LEARNING- 2/3

2. Do you think students should prepare themselves before going to geostatistics class (for instance with prior reading, e-learning…)?

   ◻ Yes ◻ No

3. Would you use the e-learning tutorial in geostatistics for your own course? (consider only pedagogical aspects)

very unlikely	unlikely	maybe	likely	very likely
1	2	3	4	5

4. Please, explain your answer above and how you would implement it (assignment before class / illustrations during class…) :

   ____

5. Do you think the e-learning tutorial in geostatistics will help you :

	very unlikely	unlikely	maybe	likely	very likely
1.Assess students' knowledge before class (Quizz)	1	2	3	4	5
2.Get students prepared to class	1	2	3	4	5
3.Improve teaching during class	1	2	3	4	5
4.Save time for class	1	2	3	4	5
5.Illustrate complex concepts	1	2	3	4	5
6.Use authentic material to provide examples and practice	1	2	3	4	5

6. What do you expect from an e-learning module for class preparation ?

   "An e-learning tutorial should…"

	strongly disagree	disagree	neutral	agree	strongly agree
1."…explain the main concepts and their relationships"	1	2	3	4	5
2."…open questions, problems that will be addressed in class"	1	2	3	4	5
3."…be short and concise"	1	2	3	4	5
4."…be exhaustive, with all the same detailed explanations as in books"	1	2	3	4	5
5."…make students confident to participate in class"	1	2	3	4	5
6."…use illustration, animation and interactivity only when necessary"	1	2	3	4	5
7."…allow to illustrate phenomenon and concepts that would take too long by other means (oral, written, drawing, simulation)"	1	2	3	4	5
8."…create interaction with the data, with the key concepts"	1	2	3	4	5
9."…include examples from the industry, from the real world"	1	2	3	4	5
10."…include exercises with feedback for students' self-assessment (quizz)"	1	2	3	4	5
11."…the practical examples and exercises should be reviewed during class"	1	2	3	4	5
12."…the completion of the module should count for students' grade"	1	2	3	4	5
13."…provide a printable file for students' future inquiries"	1	2	3	4	5

Please, go to next page →

QUESTIONNAIRE FOR INSTRUCTORS – E-LEARNING-

7. What attribute does the module in geostatistics possess ?

"The module in geostatistics …"

	strongly disagree	disagree	neutral	agree	strongly agree
1."…explains the main concepts and their relationships"	1	2	3	4	5
2."…opens questions, problems that will be addressed in class"	1	2	3	4	5
3."…is short and concise"	1	2	3	4	5
4."…is exhaustive, with all the same detailed explanations as in books"	1	2	3	4	5
5."…makes students confident to participate in class"	1	2	3	4	5
6."…uses illustration, animation and interactivity only when necessary"	1	2	3	4	5
7."…allows to illustrate phenomenon and concepts that would take too long by other means (oral, written, drawing, simulation)"	1	2	3	4	5
8."…creates interaction with the data, with the key concepts"	1	2	3	4	5
9."…includes examples from the industry, from the real world"	1	2	3	4	5

8. Is there <u>one</u> section of the module you would have designed differently?

Please choose only one of the following ☐ statistics ☐ variogram ☐ estimators ☐ simulators

What would you remove, improve or add ? ______________________________

____

9. Now, let's imagine that faculty members and corporate instructors collaborate for the design of one course material in geostatistics. In your current position as a teacher or instructor, do you think:

Statements	strongly disagree	disagree	neutral	agree	strongly agree
1.It won't work. Training needs between university and industry are too different	1	2	3	4	5
2.The industry can bring authentic/real world challenges necessary to grow engineering minds	1	2	3	4	5
3.The university knows more than industry on teaching and knowledge assessment	1	2	3	4	5
4.Political and administrative aspects will prevent such collaboration to happen (university and company decision making process)	1	2	3	4	5
5.This will never happen because my institution doesn't have any relationship with academia or industry	1	2	3	4	5
6.The collaboration will fail. Teachers and professionals don't share the same culture (public/private sector)	1	2	3	4	5
7.It will help to get various perspectives and it will contribute to enrich the teaching content	1	2	3	4	5
8.As specialists, we will hardly find an agreement on the content to include in a single learning resource	1	2	3	4	5
9.I already identified opportunities for collaboration	1	2	3	4	5
10.It will be too difficult to manage (time and place to meet, too busy…)	1	2	3	4	5
11.Sharing my teaching resources will be an issue because they reflect my knowledge in how to teach	1	2	3	4	5
12.Sharing my teaching resources will be an issue because they include some proprietary information	1	2	3	4	5
13.I am not used to work in team	1	2	3	4	5

Appendix 15. Pool of questions for the interviews.

instructor	profile	Sector	
instructor	profile	Domain	
instructor	profile	Employer	
instructor	profile	Function	
instructor	profile	Initial training (background)	
instructor	profile	Diploma	
instructor	profile	Professional experience	
instructor	profile	Professional associations	
instructor	teaching	teaching status	teacher/instructor/consultant
instructor	teaching	role, mission	traditional teaching/ facilitator/assistant professor/coach
instructor	teaching	Why do you teach? Personal interest…	interest/requested to conduct research/incomes
instructor	teaching	What kind of training does your department deliver?	
instructor	teaching	What course do you deliver?	
instructor	teaching	For each course taught, what is your level of expertise?	advanced/medium/basic
instructor	teaching	What are the learners?	students, initial education, profesional training…
instructor	teaching	Are you alone to design and produce your traditional course? Online course?	
instructor	teaching	What kind of material, learning resources do you use?	open (internet)/research work from the university/external research work/other
instructor	teaching	Do you follow any educational methodology?	Bloom's taxonomy, ADDIE
instructor	teaching	Are you involved in the curriculum development?	
instructor	teaching	Where does the course need is coming from?	locally: director of programs, managers
instructor	teaching	What do you like most in teaching? Why?	instructional design, LR production, teaching and interaction with students
instructor	teaching	Is it painful?	administration, time consuming
instructor	teaching	What teaching activities do you use?	practical work, work in teams, projects, visits, case studies, traditional class, exams, open discussions
LR	current LR	What kind of LR do you use? Before / during class	self-made material, publications, reference books, courseware, software
LR	current LR	What format?	ppt, doc, hardcopies, books…
LR	current LR	Do you share your LR with your colleagues, are they open and available, do you enrich them from colleagues' contribution?	
LR	current LR	According to you, how much of your course content belongs to the public domain? Proprietary information?	

instructor	teaching	According to you, what is the objective of a traditional class?	knowledge transmission, interaction with students, challenge students, do exercises
instructor	teaching	Is it essential and why?	
instructor	teaching	What activities are requested out of class time? Is it well accepted by the students?	readings, group work
instructor	teaching	Is it difficult to manage the time before/during/after class?	new class, well established class
instructor	teaching	How do you assess student's knowledge?	writing exams, oral discussion, surveys
instructor	teaching	Do you evaluate the knowledge transfer to real life situations? Time to competency?	
instructor	believes and attitudes	For you, what are the most important qualities a good teacher should have?	communication skills, pedagogical knowledge, content knowledge, industry relationship
instructor	believes and attitudes	What are the ways to improve them?	
instructor	believes and attitudes	How would you describe your teaching style?	flexible and open, autoritative and structured …
instructor	believes and attitudes	To explain scientific and technical concepts and principles, are you more at ease:	oral presentation / small groups / individual coaching / writing /illustrating with drawings
instructor	believes and attitudes	Are you limited by the physical constraints to illustrate your speech? (time, blackboard)	
instructor	organization	Does your university have an educational service department?	
instructor	organization	What is it mission?	
instructor	organization	Are you supported for course design and development, for instructional design, didactics?	
instructor	organization	Do you know your support contact?	
instructor	organization	Are best practices identified and shared? Are instructions on how to build a course made?	
instructor	organization	In your teaching role do you feel?	supported, autonomous, isolated
instructor	organization	Do you have some support to dvelop your material? (multimedia)?	Internal/outsourced?
instructor	organization	What department?	
instructor	organization	Do you run research activities, administrative tasks? What are the time distribution between the different missions?	
instructor	organization	Do you have a budget for your teaching activities?	
learner	pedagogy	Did you receive training in learning theories, instructional design theories and methods?	

content	didactics	Do you belong to a community of teachers, a professional association	
content	didactics	Do you share didactical approaches with your colleagues? (pedagogical knowledge in your specific domain)	
content	didactics	Do you use didactical tools?	socio-historic studies, didactic transposition, objective-obstacle, social practices of reference, conceptual frame
learner	profile	What are the general profile of your students?	age, gender, class size, profile, academic background
learner	motivation	Why do they follow your class?	initial education, curiosity
learner	pedagogy	How do you identify the student's obstacles to learn?	oral discussion, exams
learner	pedagogy	What do you assess most?	declarative knowledge, understanding, procedural knowledge, application/problem solving, analysis abilities
learner	andragogy	Do you think engineering students and professionals behave differently in regards to learning?	
learner	andragogy		
LR	ICT	How do you define e-learning? And blended learning? Can you describe it?	
LR	ICT	Did you use e-learning and blended learning yourself during you initial education? After? Can you describe it?	
LR	ICT	What are the advantages as a learner?	
LR	ICT	The cons? Drawbacks?	
LR	ICT	Did you or do you use e-learning in your class? Please describe.	
LR	ICT	What are the advantages as a teacher?	
LR	ICT	The cons? Drawbacks?	
LR	ICT	Would you like to develop e-learning? Objective, domain, modality of use, internally/yourself/externally, what are the main challenges?	
LR	ICT	Do you think scientific and engineering education should rely more on ICT? Why (visualization affordance?)?	cognitive tools
LR	ICT	Do you have a LMS?	
Methods	UBC	How do you define the university model you are working in?	liberal, research, service
Methods	UBC	Considering the learning resources, what is the strength of your institution?	
Methods	UBC	Do you know what is used in the industry for corporate training?	
Methods	UBC	Do you see some advantages/opportunities for university and business to collaborate in teaching and training?	cost sharing, best practices

Methods	UBC	What would be the main challenges? Obstacles?	IP, time loss, cultural divide
Methods	UBC	For the learners? Advantages and drawbacks?	

Appendix 16. Codification of the variables for the module usage online.

courseCode

06 = "C1_2_2_06, REPSOL, 3-4-5/02/2014"
07 = "U1_2_2_07, IFP School, 4-5-6/03/2014, RGE22"
08 = "U1_2_2b_08, IFP School, 16/06/2014, GEO18"
09 = "C2_2_2b_09, BEICIP, 14-15/04/2014"
10 = "C3_2_2b_10, IGME, 27-28-29-30/10/2014"
11 = "C4_2_4_11, Geovariances, 19-20/11/2014"

Context

0 = "University"
1 = "Business"

Track

0 = "Track 1&2"
1 = "Full Module"

Date
userCode
Name
Group
ScoreQUIZZ1
ScoreQUIZZ2
ScoreQUIZZGlobal
Comments (when exiting the module, the users could let their feedback in an input text)
Total
Totalrecalculé
structModule
Part11
Exo1
Part12
Part13
Exo2
Part21
Exo3
Part22
Part23
Exo4
Part24
Part31
Exo5
Part32
Part33
Part34
Exo6
Part41
Part42
Part43
Quizz1_Q1
Quizz1_Q2
Quizz1_Q3
Quizz1_Q4
Quizz1_Q5
Quizz1_Q6
Quizz1_Q7

Quizz1_Q8
Quizz1_Q9
Quizz1_Q10
Quizz2_Q1
Quizz2_Q2
Quizz2_Q3
Quizz2_Q4
Quizz2_Q5
Quizz2_Q6
Quizz2_Q7

Appendix 17. Descriptive analytics of the module usage.

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
ScoreQUIZZ1	77	50	50	100	77.92	1.738	15.247	232.468	-.187	.274	-.979	.541
ScoreQUIZZ2	72	72.0	28.0	100.0	69.664	2.3942	20.3159	412.734	-.248	.283	-.934	.559
ScoreQUIZZGlobal	87	100.00	.00	100.00	63.7115	2.77837	25.91492	671.583	-1.231	.258	.984	.511
Totalrecalculé	87	4:00:16	0:00:00	4:00:16	1:09:29	0:05:31	0:51:33		1.017	.258	.715	.511
structModule	87	0:41:03	0:00:00	0:41:03	0:02:07	0:00:30	0:04:46		6.986	.258	53.918	.511
Part11	87	1:10:19	0:00:00	1:10:19	0:09:00	0:01:30	0:14:02		2.589	.258	6.771	.511
Exo1	87	1:54:34	0:00:00	1:54:34	0:06:20	0:01:41	0:15:47.		4.611	.258	26.788	.511
Part12	87	0:45:50	0:00:00	0:45:50	0:03:16	0:00:50	0:07:52		4.210	.258	18.431	.511
Part13	87	0:49:09	0:00:00	0:49:09	0:04:51	0:00:53	0:08:17		3.096	.258	11.377	.511
Exo2	87	0:22:27	0:00:00	0:22:27	0:01:57	0:00:30	0:04:45		3.013	.258	8.741	.511
Part21	87	0:31:10	0:00:00	0:31:10	0:03:58	0:00:37	0:05:52		2.607	.258	7.314	.511
Exo3	87	0:22:48	0:00:00	0:22:48	0:01:31	0:00:25	0:04:01		3.503	.258	13.323	.511
Part22	87	0:56:48	0:00:00	0:56:48	0:04:21	0:00:54	0:08:32		4.805	.258	25.259	.511
Part23	87	1:02:25	0:00:00	1:02:25	0:03:07	0:00:51	0:08:02		5.798	.258	38.081	.511
Exo4	87	0:18:58	0:00:00	0:18:58	0:01:12	0:00:20	0:03:07		3.593	.258	14.635	.511
Part24	87	0:22:21	0:00:00	0:22:21	0:05:44	0:00:30	0:04:46		1.118	.258	1.402	.511
Part31	87	0:32:16	0:00:00	0:32:16	0:04:12	0:00:42	0:06:34		2.257	.258	5.013	.511
Exo5	87	1:05:24	0:00:00	1:05:24	0:01:41	0:00:47	0:07:18		7.953	.258	68.876	.511
Part32	87	0:15:25	0:00:00	0:15:25	0:01:24	0:00:15	0:02:26		3.745	.258	16.328	.511
Part33	87	0:24:44	0:00:00	0:24:44	0:01:15	0:00:20	0:03:08		5.800	.258	38.793	.511
Part34	87	0:46:38	0:00:00	0:46:38	0:03:48	0:00:51	0:07:59		3.564	.258	14.228	.511
Exo6	87	0:37:33	0:00:00	0:37:33	0:03:17	0:00:51	0:07:56		2.794	.258	7.178	.511
Part41	87	0:29:39	0:00:00	0:29:39	0:03:00	0:00:33	0:05:08		3.211	.258	11.464	.511
Part42	87	0:11:53	0:00:00	0:11:53	0:01:29	0:00:13	0:02:10		2.824	.258	9.056	.511
Part43	87	0:19:12	0:00:00	0:19:12	0:02:40	0:00:26	0:04:10		2.220	.258	5.044	.511
Quizz1_Q1	75	10	0	10	9.20	.315	2.731	7.459	-3.160	.277	8.203	.548
Quizz1_Q2	75	10	0	10	9.33	.290	2.511	6.306	-3.546	.277	10.861	.548
Quizz1_Q3	75	10	0	10	9.73	.187	1.622	2.631	-5.997	.277	34.889	.548
Quizz1_Q4	75	10	0	10	6.67	.548	4.746	22.523	-.722	.277	-1.521	.548
Quizz1_Q5	75	10	0	10	5.87	.572	4.957	24.577	-.359	.277	-1.923	.548
Quizz1_Q6	75	10	0	10	8.00	.465	4.027	16.216	-1.531	.277	.352	.548
Quizz1_Q7	75	10	0	10	5.47	.579	5.012	25.117	-.191	.277	-2.018	.548
Quizz1_Q8	75	10	0	10	7.87	.476	4.124	17.009	-1.428	.277	.040	.548
Quizz1_Q9	75	10	0	10	8.67	.395	3.422	11.712	-2.202	.277	2.924	.548
Quizz1_Q10	75	10	0	10	6.80	.542	4.696	22.054	-.788	.277	-1.418	.548
Quizz2_Q1	75	14.3	.0	14.3	11.440	.6649	5.7585	33.161	-1.531	.277	.352	.548
Quizz2_Q2	74	14.3	.0	14.3	7.343	.8365	7.1962	51.785	-.055	.279	-2.053	.552
Quizz2_Q3	74	14.3	.0	14.3	7.343	.8365	7.1962	51.785	-.055	.279	-2.053	.552
Quizz2_Q4	74	14.3	.0	14.3	10.049	.7650	6.5807	43.306	-.905	.279	-1.214	.552
Quizz2_Q5	74	14.3	.0	14.3	11.401	.6728	5.7880	33.501	-1.510	.279	.287	.552
Quizz2_Q6	74	14.3	.0	14.3	9.276	.7990	6.8733	47.242	-.636	.279	-1.641	.552
Quizz2_Q7	74	14.3	.0	14.3	6.377	.8319	7.1566	51.217	.222	.279	-2.006	.552
Valid N (listwise)	7											

Appendix 18. Descriptive analytics of the module usage for university.

Context	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
University	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
ScoreQUIZZ1	65	50	50	100	79.85	1.788	14.415	207.788	-.295	.297	-.819	.586
ScoreQUIZZ2	58	72.0	28.0	100.0	69.703	2.6954	20.5273	421.372	-.293	.314	-.900	.618
ScoreQUIZZGlobal	66	100.00	.00	100.00	70.4	2.22611	18.08500	327.067	-1.208	.295	2.403	.582
Totalrecalculé	66	4:00:16	0:00:00	4:00:16	1:07:09	0:06:25	0:52:10		1.250	.295	1.380	.582
structModule	66	0:19:02	0:00:04	0:19:06	0:01:32	0:00:17	0:02:21		6.544	.295	48.465	.582
Part11	66	1:10:19	0:00:00	1:10:19	0:10:41	0:01:55	0:15:38		2.187	.295	4.457	.582
Exo1	66	1:00:12	0:00:00	1:00:12	0:03:53	0:01:14	0:10:09		3.707	.295	15.803	.582
Part12	66	0:45:48	0:00:02	0:45:50	0:03:20	0:01:00	0:08:07		4.435	.295	20.211	.582
Part13	66	0:49:09	0:00:00	0:49:09	0:04:39	0:00:57	0:07:51		3.438	.295	15.595	.582
Exo2	66	0:22:01	0:00:00	0:22:01	0:01:09	0:00:26	0:03:33		4.271	.295	20.250	.582
Part21	66	0:25:31	0:00:00	0:25:31	0:03:33	0:00:38	0:05:11		2.580	.295	6.962	.582
Exo3	66	0:19:15	0:00:00	0:19:15	0:01:01	0:00:24	0:03:17		4.053	.295	17.654	.582
Part22	66	0:56:48	0:00:00	0:56:48	0:04:30	0:01:07	0:09:08		4.853	.295	24.827	.582
Part23	66	0:37:23	0:00:00	0:37:23	0:02:50	0:00:40	0:05:26		4.610	.295	25.821	.582
Exo4	66	0:12:12	0:00:00	0:12:12	0:00:41	0:00:15	0:02:06		3.995	.295	17.032	.582
Part24	66	0:22:21	0:00:00	0:22:21	0:06:56	0:00:34	0:04:37		1.188	.295	1.521	.582
Part31	66	0:32:16	0:00:00	0:32:16	0:04:50	0:00:52	0:07:06		2.037	.295	3.836	.582
Exo5	66	1:05:24	0:00:00	1:05:24	0:01:31	0:00:59	0:08:07		7.730	.295	61.474	.582
Part32	66	0:11:58	0:00:00	0:11:58	0:01:24	0:00:15	0:02:06		3.128	.295	11.229	.582
Part33	66	0:12:59	0:00:00	0:12:59	0:01:06	0:00:15	0:02:03		4.116	.295	19.354	.582
Part34	66	0:46:38	0:00:00	0:46:38	0:04:45	0:01:06	0:08:57		3.053	.295	10.220	.582
Exo6	66	0:31:15	0:00:00	0:31:15	0:02:24	0:00:50	0:06:52		3.341	.295	10.482	.582
Part41	66	0:22:58	0:00:00	0:22:58	0:02:43	0:00:33	0:04:35		3.082	.295	9.483	.582
Part42	66	0:08:56	0:00:00	0:08:56	0:01:22	0:00:13	0:01:46		2.381	.295	6.561	.582
Part43	66	0:19:12	0:00:00	0:19:12	0:03:09	0:00:32	0:04:24		1.986	.295	4.057	.582
Quizz1_Q1	66	10	0	10	9.24	.328	2.666	7.110	-3.282	.295	9.042	.582
Quizz1_Q2	66	10	0	10	9.24	.328	2.666	7.110	-3.282	.295	9.042	.582
Quizz1_Q3	66	10	0	10	9.85	.152	1.231	1.515	-8.124	.295	66.000	.582
Quizz1_Q4	66	10	0	10	7.12	.562	4.562	20.816	-.959	.295	-1.115	.582
Quizz1_Q5	66	10	0	10	6.06	.606	4.924	24.242	-.444	.295	-1.860	.582
Quizz1_Q6	66	10	0	10	8.18	.478	3.887	15.105	-1.689	.295	.877	.582
Quizz1_Q7	66	10	0	10	5.91	.610	4.954	24.545	-.378	.295	-1.916	.582
Quizz1_Q8	66	10	0	10	8.03	.493	4.008	16.061	-1.560	.295	.445	.582
Quizz1_Q9	66	10	0	10	8.64	.426	3.458	11.958	-2.169	.295	2.788	.582
Quizz1_Q10	66	10	0	10	6.97	.570	4.631	21.445	-.877	.295	-1.270	.582
Quizz2_Q1	66	14.3	.0	14.3	11.700	.6841	5.5577	30.888	-1.689	.295	.877	.582
Quizz2_Q2	65	14.3	.0	14.3	7.260	.8936	7.2048	51.909	-.032	.297	-2.063	.586
Quizz2_Q3	65	14.3	.0	14.3	7.260	.8936	7.2048	51.909	-.032	.297	-2.063	.586
Quizz2_Q4	65	14.3	.0	14.3	9.460	.8458	6.8192	46.502	-.699	.297	-1.560	.586
Quizz2_Q5	65	14.3	.0	14.3	11.220	.7348	5.9243	35.098	-1.418	.297	.009	.586
Quizz2_Q6	65	14.3	.0	14.3	8.800	.8696	7.0112	49.156	-.486	.297	-1.821	.586
Quizz2_Q7	65	14.3	.0	14.3	6.160	.8851	7.1362	50.926	.286	.297	-1.980	.586
Valid N (listwise)	58											

Appendix 19. Descriptive analytics of the module usage for businesses.

		N	Range	Minimum	Maximum	Mean		Std. Deviatioı	Variance	Skewness		Kurtosis	
Context Business		Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Erı	Statistic	Std. Error
B	ScoreQUIZZ1	12	50	50	100	67.50	4.626	16.026	256.818	.805	.637	-.002	1.232
	ScoreQUIZZ2	14	60.0	40.0	100.0	69.500	5.3890	20.1638	406.577	-.048	.597	-1.019	1.154
	ScoreQUIZZGlol	21	95.00	.00	95.00	42.4524	7.55708	34.63088	1199.298	-.093	.501	-1.452	.972
	Totalrecalculé	21	2:53:13	0:03:04	2:56:17	1:16:51	0:10:55	0:50:04		.285	.501	-.894	.972
	structModule	21	0:41:03	0:00:00	0:41:03	0:03:55	0:01:53	0:08:41		4.288	.501	19.024	.972
	Part11	21	0:16:45	0:00:00	0:16:45	0:03:42	0:00:49	0:03:47		2.268	.501	6.444	.972
	Exo1	21	1:54:34	0:00:00	1:54:34	0:14:02	0:05:35	0:25:35		3.358	.501	12.730	.972
	Part12	21	0:29:59	0:00:00	0:29:59	0:03:04	0:01:34	0:07:11		3.310	.501	10.887	.972
	Part13	21	0:35:48	0:00:00	0:35:48	0:05:27	0:02:07	0:09:42		2.531	.501	5.809	.972
	Exo2	21	0:22:27	0:00:00	0:22:27	0:04:27	0:01:30	0:06:54		1.631	.501	1.476	.972
	Part21	21	0:31:10	0:00:00	0:31:10	0:05:17	0:01:40	0:07:38		2.378	.501	6.072	.972
	Exo3	21	0:22:48	0:00:00	0:22:48	0:03:05	0:01:13	0:05:34		2.598	.501	7.534	.972
	Part22	21	0:29:45	0:00:00	0:29:45	0:03:52	0:01:25	0:06:29		3.446	.501	13.581	.972
	Part23	21	1:02:25	0:00:00	1:02:25	0:03:59	0:02:56	0:13:27		4.514	.501	20.546	.972
	Exo4	21	0:18:58	0:00:00	0:18:58	0:02:48	0:01:04	0:04:54		2.306	.501	5.554	.972
	Part24	21	0:10:17	0:00:00	0:10:17	0:01:56	0:00:38	0:02:56		1.752	.501	2.618	.972
	Part31	21	0:16:47	0:00:00	0:16:47	0:02:10	0:00:51	0:03:56		2.977	.501	9.737	.972
	Exo5	21	0:13:53	0:00:00	0:13:53	0:02:11	0:00:51	0:03:54		1.928	.501	3.094	.972
	Part32	21	0:15:25	0:00:00	0:15:25	0:01:26	0:00:43	0:03:20		4.025	.501	17.226	.972
	Part33	21	0:24:44	0:00:00	0:24:44	0:01:41	0:01:09	0:05:19		4.474	.501	20.287	.972
	Part34	21	0:04:22	0:00:00	0:04:22	0:00:48	0:00:13	0:01:02		2.225	.501	6.341	.972
	Exo6	21	0:37:33	0:00:00	0:37:33	0:06:05	0:02:14	0:10:18		1.957	.501	3.425	.972
	Part41	21	0:29:39	0:00:00	0:29:39	0:03:55	0:01:27	0:06:38		3.140	.501	11.766	.972
	Part42	21	0:11:53	0:00:00	0:11:53	0:01:48	0:00:41	0:03:09		2.572	.501	6.216	.972
	Part43	21	0:13:10	0:00:00	0:13:10	0:01:08	0:00:37	0:02:51		4.068	.501	17.568	.972
	Quizz1_Q1	9	10	0	10	8.89	1.111	3.333	11.111	-3.000	.717	9.000	1.400
	Quizz1_Q2	9	0	10	10	10.00	.000	.000	.000	.	.	.	.
	Quizz1_Q3	9	10	0	10	8.89	1.111	3.333	11.111	-3.000	.717	9.000	1.400
	Quizz1_Q4	9	10	0	10	3.33	1.667	5.000	25.000	.857	.717	-1.714	1.400
	Quizz1_Q5	9	10	0	10	4.44	1.757	5.270	27.778	.271	.717	-2.571	1.400
	Quizz1_Q6	9	10	0	10	6.67	1.667	5.000	25.000	-.857	.717	-1.714	1.400
	Quizz1_Q7	9	10	0	10	2.22	1.470	4.410	19.444	1.620	.717	.735	1.400
	Quizz1_Q8	9	10	0	10	6.67	1.667	5.000	25.000	-.857	.717	-1.714	1.400
	Quizz1_Q9	9	10	0	10	8.89	1.111	3.333	11.111	-3.000	.717	9.000	1.400
	Quizz1_Q10	9	10	0	10	5.56	1.757	5.270	27.778	-.271	.717	-2.571	1.400
	Quizz2_Q1	9	14.3	.0	14.3	9.533	2.3833	7.1500	51.123	-.857	.717	-1.714	1.400
	Quizz2_Q2	9	14.3	.0	14.3	7.944	2.5123	7.5368	56.803	-.271	.717	-2.571	1.400
	Quizz2_Q3	9	14.3	.0	14.3	7.944	2.5123	7.5368	56.803	-.271	.717	-2.571	1.400
	Quizz2_Q4	9	.0	14.3	14.3	14.300	.0000	.0000	.000	.	.	.	.
	Quizz2_Q5	9	14.3	.0	14.3	12.711	1.5889	4.7667	22.721	-3.000	.717	9.000	1.400
	Quizz2_Q6	9	14.3	.0	14.3	12.711	1.5889	4.7667	22.721	-3.000	.717	9.000	1.400
	Quizz2_Q7	9	14.3	.0	14.3	7.944	2.5123	7.5368	56.803	-.271	.717	-2.571	1.400
	Valid N (listwise)	9											

a. No statistics are computed for one or more split files because there are no valid cases.

Appendix 20. Codification of the variables for the questionnaire for teachers.
institutionCode

Code given to the institution
Context
0 = "University"
1 = "Business"
Name Name
Q1.1, How many years of work practice using Geostatistics ?
Q1.2, During that year(s), did you use Geostatistics ?
1 = "daily"
2 = "weekly"
3 = "monthly"
4 = "other"
Q1.2_text, Geostat use frequency, Ooher:
Q1.3, How many years do you have as a teacher in Geostatistics ?
Q1.4_1, At which level of study are your students ? (bachelor degree)
Q1.4_2, At which level of study are your students ? (master degree)
Q1.4_3, At which level of study are your students ? (professionals)
Q1.4_4, At which level of study are your students ? (other)
Q1.4_text, Level of study, other:
Q1.5_1, What kind of course material do your students use ? (powerpoint)
Q1.5_2, What kind of course material do your students use ? (word)
Q1.5_3, What kind of course material do your students use ? (lecture notes)
Q1.5_4, What kind of course material do your students use ? (textbooks)
Q1.5_5, What kind of course material do your students use ? (reference books)
Q1.5_6, What kind of course material do your students use ? (other)
Q1.5_text, Course material, other:
Q1.6, Do you share your own teaching resources ?
Q1.6_text, If you share your LR, with who?
Q1.7_1, Do you use multimedia ? (video)
Q1.7_2, Do you use multimedia ? (animations)
Q1.7_3, Do you use multimedia ? (e-learning tutorial, courseware)
Q1.7_4, Do you use multimedia ? (software)
Q1.7_5, Do you use multimedia ? (simulators)
Q1.7_6, Do you use multimedia ? (web)
Q1.7_7, Do you use multimedia ? (other)
Q1.7_text, Multimedia, other:
Q1.8_1, What teaching method(s) ? (lecture)
Q1.8_2, What teaching method(s) ? (practical work)
Q1.8_3, What teaching method(s) ? (case studies)
Q1.8_4, What teaching method(s) ? (project work in teams)
Q1.8_5, What teaching method(s) ? (individual assignments)
Q1.8_6, What teaching method(s) ? (one-to-one tutorials)
Q1.8_7, What teaching method(s) ? (other)
Q1.8_text, Teaching method, other:
Q1.9, Did you receive training in instructional design, educational sciences…?
Q1.10, At your organization, do you have the support of some people to help you design your courses?

Q1.11, Do you follow a particular theory or methodology to design your course ?
Q1.11_text, If use a theroy / methodo, which one(s) ?
Q1.12, Do you involve students when you design new course material ?
Q1.12_text, Involve students, comments :
Q2, Do you think students should prepare themselves before going to Geostatistics class ?
Q3, Would you use the e-learning tutorial in Geostatistics ? (consider only pedagogical aspects)
1 = "very unlikely"
2 = "unlikely"
3 = "maybe"
4 = "likely"
5 = "very likely"
Q4, Please, explain your answer above and how you would implement the e-tutorial:
Q5_1, It will help you...Assess students' knowledge before class (Quizz)
Q5_2, It will help you...Get students prepared to class
Q5_3, It will help you...Improve teaching during class
Q5_4, It will help you...Save time for class
Q5_5, It will help you...Illustrate complex concepts
Q5_6, It will help you...Use authentic material to provide examples and practice
1 = "very unlikely"
2 = "unlikely"
3 = "maybe"
4 = "likely"
5 = "very likely"
Q6_1, "An e-learning tutorial should…explain the main concepts and their relationships"
Q6_2, "An e-learning tutorial should…open questions, problems that will be addressed in class"
Q6_3, "An e-learning tutorial should…be short and concise"
Q6_4, "An e-learning tutorial should…be exhaustive, with all the same detailed explanations as in books"
Q6_5, "An e-learning tutorial should…make students confident to participate in class"
Q6_6, "An e-learning tutorial should…use illustration, animation and interactivity only when necessary"
Q6_7, "An e-learning tutorial should…allow to illustrate phenomenon and concepts that would take too long"
Q6_8, "An e-learning tutorial should…create interaction with the data, with the key concepts"
Q6_9, "An e-learning tutorial should…include examples from the industry, from the real world"
Q6_10, "An e-learning tutorial should…include exercises with feedback for students' self-assessment (quizz)"
Q6_11, "An e-learning tutorial should…the practical examples and exercises should be reviewed during class"
Q6_12, "An e-learning tutorial should…the completion of the module should count for students' grade"

Q6_13, "An e-learning tutorial should…provide a printable file for students' future inquiries"

1 = "strongly disagree"

2 = "disagree"

3 = "neutral"

4 = "agree"

5 = "strongly agree"

Q7_1, "The module in Geostatistics …explains the main concepts and their relationships"

Q7_2, "The module in Geostatistics …opens questions, problems that will be addressed in class"

Q7_3, "The module in Geostatistics …is short and concise"

Q7_4, "The module in Geostatistics …is exhaustive, with all the same detailed explanations as in books"

Q7_5, "The module in Geostatistics …makes students confident to participate in class"

Q7_6, "The module in Geostatistics …uses illustration, animation and interactivity only when necessary"

Q7_7, "The module in Geostatistics …allows to illustrate phenomenon and concepts that would take too long "

Q7_8, "The module in Geostatistics …creates interaction with the data, with the key concepts"

Q7_9, "The module in Geostatistics …includes examples from the industry, from the real world"

1 = "strongly disagree"

2 = "disagree"

3 = "neutral"

4 = "agree"

5 = "strongly agree"

Q8_1, Is there one section of the module you would have designed differently? (statistics)

Q8_2, Is there one section of the module you would have designed differently? (variogram)

Q8_3, Is there one section of the module you would have designed differently? (estimators)

Q8_4, Is there one section of the module you would have designed differently? (simulators)

Q8_text, What would you remove, improve or add ?

Q9_1, UBC. It won't work. Training needs between university and industry are too different

Q9_2, UBC. The industry can bring authentic/real world challenges necessary to grow engineering minds

Q9_3, UBC. The university knows more than industry on teaching and knowledge assessment

Q9_4, UBC. Political and administrative aspects will prevent such collaboration to happen

Q9_5, UBC. This will never happen because my institution doesn't have any relationship with academia or industry

Q9_6, UBC. The collaboration will fail. Teachers and professionals don't share the same culture (public/private sector)

Q9_7, UBC. It will help to get various perspectives and it will contribute to enrich the teaching content

Q9_8, UBC. As specialists, we will hardly find an agreement on the content to include in a single learning resource

Q9_9, UBC. I already identified opportunities for collaboration

Q9_10, UBC. It will be too difficult to manage (time and place to meet, too busy…)

Q9_11, UBC. Sharing my teaching resources will be an issue because they reflect my knowledge in how to teach

Q9_12, UBC. Sharing my teaching resources will be an issue because they include some proprietary information

Q9_13, UBC. I am not used to work in team

1 = "strongly disagree"

2 = "disagree"

3 = "neutral"

4 = "agree"

5 = "strongly agree"

Extra Extra

Appendix 21. Descriptive analytics of the questionnaires for teachers.

Descriptive Statistics												
	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Context	11	1	0	1	.82	.122	.405	.164	-1.923	.661	2.037	1.279
Q1.1	10	28.5	1.5	30.0	13.050	3.1273	9.8895	97.803	.848	.687	-.290	1.334
Q1.2	10	3	1	4	2.00	.394	1.247	1.556	.859	.687	-.912	1.334
Q1.3	9	24.0	1.0	25.0	7.556	2.7882	8.3645	69.965	1.293	.717	1.058	1.400
Q1.4_1	3	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q1.4_2	5	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q1.4_3	8	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q1.4_4	0											
Q1.5_1	10	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q1.5_2	3	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q1.5_3	3	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q1.5_4	1	0	1	1	1.00	.	.	.	.	.	.	.
Q1.5_5	3	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q1.5_6	3	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q1.6	10	1	0	1	.60	.163	.516	.267	-.484	.687	-2.277	1.334
Q1.7_1	0											
Q1.7_2	3	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q1.7_3	2	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q1.7_4	10	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q1.7_5	1	0	1	1	1.00	.	.	.	.	.	.	.
Q1.7_6	1	0	1	1	1.00	.	.	.	.	.	.	.
Q1.7_7	0											
Q1.8_1	7	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q1.8_2	8	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q1.8_3	5	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q1.8_4	2	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q1.8_5	2	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q1.8_6	3	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q1.8_7	1	0	1	1	1.00	.	.	.	.	.	.	.
Q1.9	10	1	0	1	.30	.153	.483	.233	1.035	.687	-1.224	1.334
Q1.10	10	1	0	1	.70	.153	.483	.233	-1.035	.687	-1.224	1.334
Q1.11	10	0	0	0	.00	.000	.000	.000	.	.	.	.
Q1.12	10	1	0	1	.60	.163	.516	.267	-.484	.687	-2.277	1.334
Q2	11	1	0	1	.91	.091	.302	.091	-3.317	.661	11.000	1.279
Q3	11	4	1	5	3.55	.455	1.508	2.273	-.748	.661	-.539	1.279
Q5_1	11	2	3	5	4.09	.251	.831	.691	-.190	.661	-1.485	1.279
Q5_2	11	4	1	5	4.00	.381	1.265	1.600	-1.449	.661	2.135	1.279
Q5_3	11	4	1	5	3.55	.366	1.214	1.473	-.949	.661	.654	1.279
Q5_4	11	4	1	5	3.27	.407	1.348	1.818	-.005	.661	-.898	1.279
Q5_5	11	4	1	5	2.91	.436	1.446	2.091	.190	.661	-1.245	1.279
Q5_6	10	4	1	5	3.00	.422	1.333	1.778	-.352	.687	-.748	1.334
Q5_1	11	1	4	5	4.36	.152	.505	.255	.661	.661	-1.964	1.279
Q6_2	11	2	3	5	4.18	.226	.751	.564	-.329	.661	-.878	1.279
Q6_3	11	2	3	5	4.36	.203	.674	.455	-.593	.661	-.293	1.279
Q6_4	11	4	1	5	2.18	.325	1.079	1.164	1.907	.661	4.964	1.279
Q6_5	11	3	2	5	3.82	.296	.982	.964	-.346	.661	-.587	1.279
Q6_6	11	3	2	5	3.36	.310	1.027	1.055	.448	.661	-.594	1.279
Q6_7	11	4	1	5	3.09	.392	1.300	1.691	-.535	.661	-.598	1.279
Q6_8	10	3	1	4	3.50	.307	.972	.944	-2.270	.687	5.356	1.334
Q6_9	11	4	1	5	3.55	.340	1.128	1.273	-1.414	.661	1.781	1.279
Q6_10	11	2	3	5	4.18	.226	.751	.564	-.329	.661	-.878	1.279
Q6_11	11	3	2	5	4.09	.315	1.044	1.091	-.856	.661	-.260	1.279
Q6_12	9	3	2	5	2.89	.309	.928	.861	1.470	.717	3.281	1.400
Q6_13	11	3	2	5	3.64	.338	1.120	1.255	-.155	.661	-1.225	1.279
Q7_1	11	3	2	5	4.00	.234	.775	.600	-1.578	.661	5.000	1.279
Q7_2	11	3	2	5	3.55	.312	1.036	1.073	-.147	.661	-.853	1.279

Q7_3	11	1	4	5	4.27	.141	.467	.218	1.189	.661	-.764	1.279
Q7_4	11	3	1	4	1.91	.285	.944	.891	1.081	.661	1.206	1.279
Q7_5	11	2	2	4	3.45	.207	.688	.473	-.932	.661	.081	1.279
Q7_6	10	2	3	5	3.70	.260	.823	.678	.687	.687	-1.043	1.334
Q7_7	11	4	1	5	3.18	.400	1.328	1.764	-.714	.661	-.604	1.279
Q7_8	10	2	2	4	3.40	.221	.699	.489	-.780	.687	-.146	1.334
Q7_9	11	2	2	4	3.27	.273	.905	.818	-.647	.661	-1.548	1.279
Q8_1	1	0	1	1	1.00	.	.	.	.	.	.	.
Q8_2	2	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q8_3	1	0	1	1	1.00	.	.	.	.	.	.	.
Q8_4	3	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q9_1	11	3	1	4	2.55	.282	.934	.873	.290	.661	-.501	1.279
Q9_2	11	2	3	5	4.27	.195	.647	.418	-.291	.661	-.208	1.279
Q9_3	11	2	2	4	2.73	.237	.786	.618	.574	.661	-.967	1.279
Q9_4	11	4	1	5	2.64	.364	1.206	1.455	.446	.661	.129	1.279
Q9_5	11	2	1	3	1.73	.237	.786	.618	.574	.661	-.967	1.279
Q9_6	11	2	1	3	2.00	.191	.632	.400	.000	.661	.417	1.279
Q9_7	11	2	3	5	4.00	.135	.447	.200	.000	.661	5.000	1.279
Q9_8	11	2	2	4	2.91	.285	.944	.891	.209	.661	-2.069	1.279
Q9_9	11	2	2	4	3.09	.211	.701	.491	-.123	.661	-.453	1.279
Q9_10	11	2	2	4	3.09	.251	.831	.691	-.190	.661	-1.485	1.279
Q9_11	11	3	1	4	2.73	.333	1.104	1.218	.108	.661	-1.597	1.279
Q9_12	11	4	1	5	3.27	.407	1.348	1.818	-.902	.661	-.475	1.279
Q9_13	11	1	1	2	1.36	.152	.505	.255	.661	.661	-1.964	1.279
Valid N (listwise)	0											

Appendix 22. Open answers of the questionnaire for teachers.

	Geostat use frequency, Ooher:	Level of study, other:	Course material, other:	If you share your LR, with who?	Multimedia, other:	Teaching method, other:	If use a theroy / methodo, which one(s)?	Involve students, comments :	Please, explain your answer above and how you would implement the e-tutorial:	What would you remove, improve or add ?	Extra
1			e-learning	there is no other instructor				after feedback	Illutrate better the basics concepts and put all students in context	to explain better and have more time for each algorithm	
2	when necessary 1 study a year approx			staff at IFP School, staff at IFP-training	e-learning (yours)				before class as a course preparation	I would add a geological framework to introduce simulations	
3			software						maybe as a preparation before training itself		De mon côté, je suis assez contente d'avoir effectué cette démarche qui a permis à des utilisateursd novices d'avoir quelques notions de base *(for my part, I am pleased to have applied this olutions in order to enable learners to get basic knowledge)*
4									It needs much more explanation about the meaning of variogram and different	Semivariogram is not used anymore, use variogram. Explain better the meaning of variogram, the	

									Krigging types	importance of modeling and the different kind of kriging. I miss all these items	
5											
6										Too concise, too much ambiguity between experimental variogram and model	
7									I would use in all process of learning		
8			PDF and tutorials (exercise)	colleague				indirectly through student feedback	As an assignment before class and review during the class. It is important for students to have some commitments for the teaching to be effective.	Maybe improve a bit the simulations	
9				Researcher at IFP	PPT files	practical work with softwares		clients remarks	I think it will be indeed better that students prepare themselves before Geostatistics class. I think it is good that students can access content before they go to geostatistical class.	no	
10				colleagues				asking feedback	Better options but with the need to adapt some aspects	Answering this question will require more than 2 lines. We will discuss it on the phone.	
11	From time to time,			colleagues					I am teaching mainly to professiona		

	when needed in professional practice								ls (not juniors in training phase). Their operational constraints do not allow them to take time to prepare courses. It is not realistic to expect such an implication from them.		
	11	11	11	11	11	11	11	11	11	11	11

Appendix 23. Codification of the variables for the questionnaire for learners.

courseCode, Code given to the course

06 = "C1_2_2_06, REPSOL, 3-4-5/02/2014"
07 = "U1_2_2_07, IFP School, 4-5-6/03/2014, RGE22"
08 = "U1_2_2b_08, IFP School, 16/06/2014, GEO18"
09 = "C2_2_2b_09, BEICIP, 14-15/04/2014"
10 = "C3_2_2b_10, IGME, 27-28-29-30/10/2014"
11 = "C4_2_4_11, Geovariances, 19-20/11/2014"

Context, University or Business

0 = "University"
1 = "Business"

Q1, gender

0 = "Male"
1 = "Female"

Q2, what is your age ?

1 = "<23"
2 = "23-25"
3 = "26-29"
4 = "30-34"
5 = "35-39"
6 = "40-44"
7 = "45-49"
8 = "50-54"
9 = "55-59"
10 = ">59"

Q2_1, Age (5 points scale)

1.00 = "<23"
2.00 = "26-34"
3.00 = "35-44"
4.00 = "45-54"
5.00 = ">55"

Q3, Is it your first training or first class in Geostatistics ?

Q4, Is it the first time you combine both e-learning and classroom sessions in a single course?

Q5, Are you satisfied with the e-learning tutorial ?

1.0 = "not at all"
2.0 = "a little"
3.0 = "a fair amount"
4.0 = "much"
5.0 = "very much"

Q6, Satisfaction ,please, explain your answer above :

Q7, How much did you learn from the e-learning tutorial ?

1.0 = "nothing"
2.0 = "not much"
3.0 = "a little bit"
4.0 = "quite a bit"
5.0 = "a lot"

Q8, What did you learn most from the e-learning module ?

Q9_1, How often ? (daily)
Q9_2, How often ? (weekly)
Q9_3, How often ? (monthly)
Q9_4, How often ? (very few)
Q9_5, How often ? (I don't know)
Q9_6, How often / scale
Q9_62, Usefulness
Q9_7, How often /4=5
Q10, How much time are you ready to dedicate in minutes ?
Q10_1, How much time / scale

1 = "less than 10"
2 = "between 10 and 20"
3 = "between 20 and 40"
4 = "between 40 and 60"
5 = "more than 60"

Q11, Was it easy to dedicate some time in order to complete the e-learning module before class ?

1 = "very difficult"
2 = "difficult"
3 = "neither easy nor difficult"
4 = "easy"
5 = "very easy"

Q11_bis, Time / dedication, why ?
Q12_1, Where did you complete the e-learning tutorial ? (at home)
Q12_2, Where did you complete the e-learning tutorial ? (at office)
Q12_3, Where did you complete the e-learning tutorial ? (other)
Q13_1, When did you complete the e-learning tutorial ? (work hours)
Q13_2, When did you complete the e-learning tutorial ? (during class)
Q13_3, When did you complete the e-learning tutorial ? (lunch time)
Q13_4, When did you complete the e-learning tutorial ? (break time)
Q13_5, When did you complete the e-learning tutorial ? (evening time)
Q13_6, When did you complete the e-learning tutorial ? (week-end)
Q14_1, "An e-learning tutorial should…explain the main concepts and their relationships"
Q14_2, "An e-learning tutorial should…open questions, problems that will be addressed in class"
Q14_3, "An e-learning tutorial should…be short and concise"
Q14_4, "An e-learning tutorial should…be exhaustive, with all the same detailed explanations as in books"
Q14_5, "An e-learning tutorial should…make me confident to participate in class"
Q14_6, "An e-learning tutorial should…use illustration, animation and interactivity only when necessary"
Q14_7, "An e-learning tutorial should…create interaction with the data, with the key concepts"
Q14_8, "An e-learning tutorial should…include examples from the industry, from the real world"
Q14_9, "An e-learning tutorial should…include exercises with feedback for self-assessment (quizz)"
Q14_10, "An e-learning tutorial should…the practical examples and exercises should be reviewed during class"

Q14_11, “An e-learning tutorial should…the completion of the module should count for my grade”

Q14_12, “An e-learning tutorial should…provide a printable file for future inquiries”

Q15_1, “The module in Geostatistics …explains the main concepts and their relationships”

Q15_2, “The module in Geostatistics …opens questions, problems that will be addressed in class”

Q15_3, “The module in Geostatistics …is short and concise”

Q15_4, “The module in Geostatistics …is exhaustive, with all the same detailed explanations as in books”

Q15_5, “The module in Geostatistics …makes me confident to participate in class”

Q15_6, “The module in Geostatistics …uses illustration, animation and interactivity only when necessary”

Q15_7, “The module in Geostatistics …creates interaction with the data, with the key concepts”

Q15_8, “The module in Geostatistics …includes examples from the industry, from the real world”

1 = "strongly disagree"
2 = "disagree"
3 = "neutral"
4 = "agree"
5 = "strongly agree"

Q16_1, Is there one section of the module you would have designed differently ? statistics

Q16_2, Is there one section of the module you would have designed differently ? variogram

Q16_3, Is there one section of the module you would have designed differently ? estimators

Q16_4, Is there one section of the module you would have designed differently ? simulators

Q16_text, What would you remove, improve or add ?

Q17, Do you have any comments you would like to share with us ?

Q18, Are your willing to participate in further research on e-learning ?

FAC1_2, A-R factor score 1 for analysis 2

FAC2_2, A-R factor score 2 for analysis 2

FAC3_2, A-R factor score 3 for analysis 2

Appendix 24. Descriptive analytics of the questionnaires for learners.

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Number of learners in that course	78	37	5	42	25.47	1.687	14.899	221.967	-.329	.272	-1.549	.538
Number of learners who answered the questionnaire	78	23	4	27	18.67	1.095	9.671	93.524	-.622	.272	-1.567	.538
gender	75	1	0	1	.36	.056	.483	.234	.595	.277	-1.691	.548
what is your age ?	76	6	1	7	3.16	.181	1.575	2.481	.867	.276	-.131	.545
Age (5 points scale)	76	3.00	1.00	4.00	1.8421	.10096	.88019	.775	.679	.276	-.510	.545
Is it your first training or first class in Geostatistics ?	78	1	0	1	.69	.053	.465	.216	-.850	.272	-1.312	.538
Is it the first time you combine both e-learning and classroom sessions in a single course?	77	1	0	1	.77	.049	.426	.181	-1.283	.274	-.363	.541
Are you satisfied with the e-learning tutorial ?	76	4.0	1.0	5.0	3.599	.0946	.8247	.680	-.636	.276	.529	.545
How much did you learn from the e-learning tutorial ?	76	3.0	2.0	5.0	3.586	.0993	.8656	.749	-.081	.276	-.589	.545
How often ? (daily)	4	0	1	1	1.00	.000	.000	.000	.	.	.	.
How often ? (weekly)	8	0	1	1	1.00	.000	.000	.000	.	.	.	.
How often ? (monthly)	16	0	1	1	1.00	.000	.000	.000	.	.	.	.
How often ? (very few)	18	0	1	1	1.00	.000	.000	.000	.	.	.	.
How often ? (I don't know)	31	0	1	1	1.00	.000	.000	.000	.	.	.	.
How often / scale	75	4	1	5	3.81	.142	1.227	1.505	-.715	.277	-.515	.548
Usefulness	75	4	1	5	2.19	.142	1.227	1.505	.715	.277	-.515	.548
How often /4=5	75	4	1	5	4.04	.154	1.330	1.769	-.925	.277	-.601	.548
How much time are you ready to dedicate in minutes ?	73	150	0	150	46.10	3.897	33.294	1108.505	1.155	.281	1.015	.555
How much time / scale	73	4	1	5	3.68	.145	1.235	1.524	-.372	.281	-1.017	.555
Q11	77	5	0	5	3.38	.129	1.136	1.290	-.626	.274	.318	.541
Q12_1	53	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q12_2	19	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q12_3	7	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q13_1	14	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q13_2	4	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q13_3	2	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q13_4	5	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q13_5	43	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q13_6	17	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q14_1	75	2	3	5	4.59	.066	.572	.327	-1.019	.277	.077	.548
Q14_2	73	5	0	5	3.77	.126	1.074	1.153	-1.315	.281	2.879	.555
Q14_3	73	5	0	5	3.92	.128	1.090	1.188	-1.223	.281	1.603	.555
Q14_4	75	4	1	5	2.52	.129	1.119	1.253	.335	.277	-.710	.548
Q14_5	75	5	0	5	3.64	.132	1.147	1.315	-.907	.277	1.219	.548
Q14_6	73	4	1	5	3.93	.131	1.122	1.259	-1.014	.281	.536	.555
Q14_7	74	3	2	5	4.34	.089	.763	.583	-1.233	.279	1.668	.552
Q14_8	75	3	2	5	3.97	.102	.885	.783	-.428	.277	-.653	.548
Q14_9	75	4	1	5	4.17	.106	.921	.848	-1.316	.277	2.193	.548
Q14_10	71	3	2	5	4.00	.122	1.028	1.057	-.730	.285	-.598	.563
Q14_11	74	4	1	5	2.65	.145	1.243	1.546	.089	.279	-.997	.552
Q14_12	75	4	1	5	4.11	.113	.981	.961	-1.102	.277	1.109	.548
Q15_1	73	3	2	5	4.12	.087	.744	.554	-.827	.281	1.057	.555
Q15_2	71	4	1	5	3.66	.106	.894	.798	-1.001	.285	1.728	.563
Q15_3	73	3	2	5	3.81	.097	.828	.685	-.230	.281	-.490	.555
Q15_4	73	4	1	5	2.52	.116	.988	.975	.208	.281	-.634	.555
Q15_5	73	4	1	5	3.45	.107	.913	.834	-.023	.281	-.257	.555
Q15_6	72	4	1	5	3.83	.120	1.021	1.042	-.554	.283	-.415	.559
Q15_7	73	3	2	5	3.93	.096	.822	.676	-.179	.281	-.825	.555
Q15_8	72	4	1	5	2.96	.147	1.250	1.562	.125	.283	-.839	.559

Q16_1	6	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q16_2	14	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q16_3	5	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q16_4	17	0	1	1	1.00	.000	.000	.000	.	.	.	.
A-R factor score 1 for analysis 2	64	4.59417	-2.60925	1.98492	.0367436	.12804029	1.02432231	1.049	-.285	.299	-.476	.590
A-R factor score 2 for analysis 2	64	4.24688	-2.85692	1.38997	.0518210	.12051506	.96412051	.930	-.949	.299	.690	.590
A-R factor score 3 for analysis 2	64	4.38719	-2.37696	2.01023	-.0436855	.12352711	.98821690	.977	-.025	.299	-.328	.590
Valid N (listwise)	0											

Appendix 25. Descriptive analytics of the questionnaires for learners (university).

	N	Rang	Mini	Maxi	Mean		Std. De	Variar	Skewness		Kurtosis	
University	Stat	Statis	Statis	Statis	Statistic	Std. E	Statistic	Statist	Statist	Std.	Statistic	Std.
Number of learners in that c	56	35	7	42	33.09	1.344	10.060	101.21	-1.344	.319	1.719	.628
Number of learners who ar questionnaire	56	22	5	27	23.75	.815	6.097	37.173	-2.665	.319	5.942	.628
gender	55	1	0	1	.29	.062	.458	.210	.947	.322	-1.147	.634
what is your age ?	56	5	1	6	2.54	.135	1.008	1.017	1.168	.319	2.065	.628
Age (5 points scale)	56	2.00	1.00	3.00	1.4821	.08055	.60275	.363	.846	.319	-.227	.628
Is it your first training or fi Geostatistics ?	56	1	0	1	.66	.064	.478	.228	-.698	.319	-1.571	.628
Is it the first time you comb learning and classroom ses single course?	56	1	0	1	.73	.060	.447	.200	-1.078	.319	-.871	.628
Are you satisfied with the tutorial ?	54	4.0	1.0	5.0	3.704	.1171	.8607	.741	-.851	.325	1.061	.639
How much did you learn f learning tutorial ?	54	3.0	2.0	5.0	3.704	.1229	.9034	.816	-.323	.325	-.564	.639
How often ? (daily)	4	0	1	1	1.00	.000	.000	.000	.	.	.	.
How often ? (weekly)	6	0	1	1	1.00	.000	.000	.000	.	.	.	.
How often ? (monthly)	9	0	1	1	1.00	.000	.000	.000	.	.	.	.
How often ? (very few)	13	0	1	1	1.00	.000	.000	.000	.	.	.	.
How often ? (I don't know)	24	0	1	1	1.00	.000	.000	.000	.	.	.	.
How often / scale	54	4	1	5	3.81	.177	1.304	1.701	-.809	.325	-.508	.639
Usefulness	54	4	1	5	2.19	.177	1.304	1.701	.809	.325	-.508	.639
How often /4=5	54	4	1	5	4.04	.191	1.400	1.961	-1.010	.325	-.517	.639
How much time are you dedicate in minutes ?	52	150	0	150	44.23	4.629	33.378	1114.1	1.406	.330	1.748	.650
How much time / scale	52	4	1	5	3.60	.168	1.209	1.461	-.130	.330	-1.300	.650
Q11	55	5	0	5	3.64	.131	.969	.939	-.845	.322	2.327	.634
Q12_1	44	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q12_2	4	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q12_3	7	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q13_1	1	0	1	1	1.00	.	.	.	.	.	.	.
Q13_2	0											
Q13_3	1	0	1	1	1.00	.	.	.	.	.	.	.
Q13_4	3	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q13_5	37	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q13_6	14	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q14_1	54	2	3	5	4.54	.078	.573	.329	-.773	.325	-.376	.639
Q14_2	52	5	0	5	3.67	.159	1.150	1.322	-1.408	.330	2.715	.650
Q14_3	52	5	0	5	3.88	.147	1.060	1.124	-1.303	.330	2.375	.650
Q14_4	54	4	1	5	2.59	.148	1.091	1.189	.252	.325	-.684	.639
Q14_5	54	5	0	5	3.70	.162	1.192	1.420	-1.201	.325	1.989	.639
Q14_6	52	4	1	5	4.15	.141	1.017	1.035	-1.367	.330	1.881	.650
Q14_7	53	3	2	5	4.38	.105	.765	.586	-1.308	.327	1.801	.644
Q14_8	54	3	2	5	4.00	.127	.932	.868	-.582	.325	-.541	.639
Q14_9	54	4	1	5	4.26	.119	.873	.762	-1.425	.325	2.708	.639
Q14_10	51	3	2	5	4.02	.141	1.010	1.020	-.768	.333	-.459	.656
Q14_11	53	4	1	5	2.60	.169	1.230	1.513	.170	.327	-1.025	.644
Q14_12	54	4	1	5	4.02	.139	1.019	1.037	-1.039	.325	1.045	.639
Q15_1	53	3	2	5	4.13	.093	.680	.463	-.549	.327	.750	.644
Q15_2	51	4	1	5	3.75	.115	.821	.674	-.843	.333	1.621	.656
Q15_3	53	3	2	5	3.75	.111	.806	.650	-.203	.327	-.355	.644
Q15_4	53	4	1	5	2.57	.144	1.047	1.097	.132	.327	-.779	.644
Q15_5	53	4	1	5	3.51	.131	.953	.909	-.236	.327	-.235	.644
Q15_6	52	4	1	5	3.81	.143	1.030	1.060	-.606	.330	-.223	.650
Q15_7	53	3	2	5	3.92	.111	.805	.648	-.090	.327	-.913	.644
Q15_8	52	4	1	5	3.08	.180	1.296	1.680	.021	.330	-.948	.650
Q16_1	3	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q16_2	13	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q16_3	3	0	1	1	1.00	.000	.000	.000	.	.	.	.
Q16_4	14	0	1	1	1.00	.000	.000	.000	.	.	.	.
A-R factor score 1 for ana	47	4.594	-2.60	1.984	.166966	.15520	1.06405	1.132	-.532	.347	-.117	.681

	A-R factor score 2 for ana	47	4.09	-2.70	1.38	.16195	.1347	.92364	.853	-.939	.347	.644	.681
	A-R factor score 3 for ana	47	3.72	-2.37	1.34	-.31562	.1305	.89472	.801	-.132	.347	-.321	.681
	Valid N (listwise)	0											

Appendix 26. Descriptive analytics of the questionnaires for learners (business).

	BUSINESS												
	Number of learners in that course	22	2	5	7	6.09	.160	.750	.563	-.154	.491	-1.106	.953
	Number of learners who answered the questionnaire	22	3	4	7	5.73	.239	1.120	1.255	-.297	.491	-1.253	.953
	gender	20	1	0	1	.55	.114	.510	.261	-.218	.512	-2.183	.992
	what is your age ?	20	6	1	7	4.90	.355	1.586	2.516	-.786	.512	.429	.992
	Age (5 points scale)	20	3.00	1.00	4.00	2.8500	.16662	.74516	.555	-.591	.512	.925	.992
	Is it your first training or first class in Geostatistics ?	22	1	0	1	.77	.091	.429	.184	-1.399	.491	-.057	.953
	Is it the first time you combine both e-learning and classroom sessions in a single course?	21	1	0	1	.86	.078	.359	.129	-2.202	.501	3.138	.972
	Are you satisfied with the e-learning tutorial ?	22	2.0	2.0	4.0	3.341	.1448	.6794	.462	-.486	.491	-.811	.953
	How much did you learn from the e-learning tutorial ?	22	3.0	2.0	5.0	3.295	.1495	.7013	.492	.365	.491	.619	.953
	How often ? (daily)	0											
	How often ? (weekly)	2	0	1	1	1.00	.000	.000	.000	.	.	.	.
	How often ? (monthly)	7	0	1	1	1.00	.000	.000	.000	.	.	.	.
	How often ? (very few)	5	0	1	1	1.00	.000	.000	.000	.	.	.	.
	How often ? (I don't know)	7	0	1	1	1.00	.000	.000	.000	.	.	.	.
	How often / scale	21	3	2	5	3.81	.225	1.030	1.062	-.188	.501	-1.202	.972
	Usefulness	21	3	1	4	2.19	.225	1.030	1.062	.188	.501	-1.202	.972
	How often /4=5	21	3	2	5	4.05	.253	1.161	1.348	-.525	.501	-1.520	.972
	How much time are you ready to dedicate in minutes ?	21	120	0	120	50.71	7.297	33.440	1118.214	.631	.501	.106	.972
	How much time / scale	21	4	1	5	3.90	.284	1.300	1.690	-1.014	.501	.292	.972
	Q11	22	4	1	5	2.73	.273	1.279	1.636	.114	.491	-.888	.953
	Q12_1	9	0	1	1	1.00	.000	.000	.000	.	.	.	.
	Q12_2	15	0	1	1	1.00	.000	.000	.000	.	.	.	.
	Q12_3	0											
	Q13_1	13	0	1	1	1.00	.000	.000	.000	.	.	.	.
	Q13_2	4	0	1	1	1.00	.000	.000	.000	.	.	.	.
	Q13_3	1	0	1	1	1.00	.	.	.	.	.	.	.
	Q13_4	2	0	1	1	1.00	.000	.000	.000	.	.	.	.
	Q13_5	6	0	1	1	1.00	.000	.000	.000	.	.	.	.
	Q13_6	3	0	1	1	1.00	.000	.000	.000	.	.	.	.
	Q14_1	21	2	3	5	4.71	.122	.561	.314	-1.920	.501	3.182	.972
	Q14_2	21	2	3	5	4.00	.183	.837	.700	.000	.501	-1.579	.972
	Q14_3	21	4	1	5	4.00	.258	1.183	1.400	-1.201	.501	.764	.972
	Q14_4	21	4	1	5	2.33	.261	1.197	1.433	.630	.501	-.433	.972
	Q14_5	21	3	2	5	3.48	.225	1.030	1.062	.070	.501	-1.031	.972
	Q14_6	21	4	1	5	3.38	.263	1.203	1.448	-.452	.501	-.284	.972
	Q14_7	21	3	2	5	4.24	.168	.768	.590	-1.184	.501	2.336	.972
	Q14_8	21	2	3	5	3.90	.168	.768	.590	.170	.501	-1.206	.972
	Q14_9	21	4	1	5	3.95	.223	1.024	1.048	-1.134	.501	1.939	.972
	Q14_10	20	3	2	5	3.95	.246	1.099	1.208	-.685	.512	-.789	.992
	Q14_11	21	4	1	5	2.76	.284	1.300	1.690	-.115	.501	-.789	.972
	Q14_12	21	3	2	5	4.33	.187	.856	.733	-1.271	.501	1.292	.972
	Q15_1	20	3	2	5	4.10	.204	.912	.832	-1.138	.512	1.157	.992
	Q15_2	20	4	1	5	3.45	.235	1.050	1.103	-1.066	.512	1.494	.992
	Q15_3	20	3	2	5	3.95	.198	.887	.787	-.398	.512	-.526	.992
	Q15_4	20	3	1	4	2.40	.184	.821	.674	.355	.512	-.065	.992
	Q15_5	20	3	2	5	3.30	.179	.801	.642	.736	.512	.574	.992
	Q15_6	20	3	2	5	3.90	.228	1.021	1.042	-.442	.512	-.905	.992

	Q15_7	20	3	2	5	3.95	.198	.887	.787	-.398	.512	-.526	.992
	Q15_8	20	4	1	5	2.65	.244	1.089	1.187	.250	.512	-.263	.992
	Q16_1	3	0	1	1	1.00	.000	.000	.000	.	.	.	.
	Q16_2	1	0	1	1	1.00	.	.	.	.	.	.	.
	Q16_3	2	0	1	1	1.00	.000	.000	.000	.	.	.	.
	Q16_4	3	0	1	1	1.00	.000	.000	.000	.	.	.	.
	A-R factor score 1 for analysis 2	17	2.53163	-1.40547	1.12616	-.3232852	.20128190	.82990653	.689	.219	.550	-1.415	1.063
	A-R factor score 2 for analysis 2	17	3.83853	-2.85692	.98161	-.2526680	.25125301	1.03594271	1.073	-1.030	.550	1.004	1.063
	A-R factor score 3 for analysis 2	17	2.51651	-.50627	2.01023	.7081490	.20664435	.85201648	.726	.029	.550	-1.459	1.063

Appendix 27. Open answers of the questionnaire for learners.

		Code given to the learner	Satisfaction ,please, explain your answer above :	What did you learn most from the e-learning module ?	Time / dedication, why ?	What would you remove, improve or add ?	Do you have any comments you would like to share with us ?	Are your willing to participate in further research on e-learning ?
1		06_01	should be delivered earlier (1 month before instead of 1 week)	prefer classroom learning	Commitment to work at office. Late delivery of module. During class (after explanations from teacher), couldn'ty complete on week-end			
2		06_02	I think is OK in terms of theory part but I think it needs to be improved in term of explanation for the exercises		My daily work	Exercises, explanation to fill them out.		
3		06_03	Theoretical part OK. Exercises need more explanation.	Exercises, how to use, build and what represent some functions, parameters.	Not much time required. Can be done from home by VPN.	It's OK for a fundamentals course.	It has been a good experience to better use resources (suit 3 day course)	X
4		06_04						
5		06_05	I did not get all the information, it was not clear.	The exercises	Lack of time out of normal working days and peacefulness to do it	more technical information about the concepts	no	
6		06_06	It's well explained and organized	basic definitions	I'm working part time	I would add more examples from Repsol		
7		06_07	I did not receive any infos about e-learning before the training			Try to simplify more this module.	no	yes, X
Total	N	7	7	7	7	7	7	7
1		07_01	It is clear, examples enable to better understand.	Variogram, kriging, estimation / simulation	short sessions	Exercises in Excel format should have answers in protected cells (highlight green/red if true/false)	Go on with the good work!	

2	07_02	It is a good introduction	Going on wikipedia after to learn about the concepts	I was tired	an animation of variogram computation on a dataset	It is not clear whether we should do the exercises fully or not (how much time should it take?)	no
3	07_03	Maybe a more detailed infeormation of references are required	statistics		more applied examples	very complete	no
4	07_04	Explanation may be more abundant, as currently it is restricted a bit	General points (variogram, distribution, explanations of estimations and simulations, methods)	I plan my time correctly and was aware about deadline	more examples and application of simulators	no	X
5	07_05	only few explanation, too short	the quizz	depend on the load in the week	I would explain more	more explanation	
6	07_06	It combines both theory and practice		we are hero to study	add more information theoretics		
7	07_07	Certain notions were not clear and we needed more explanation	It was a good introduction to basics notions of Geostatistics .	It doesn't take long time to do the e-learning	Simulation part needs more explanations	Make more illustration for the theoretical notions	no
8	07_08	very little information and explanation provided in e-learning. If something is not understood, you are stuck with the exercises and you are not able to continue.	Not much. I understood much better with the explanation given at the course.	It was easy since my priority is to study. It was difficult since I would prefer to rest during leisure time.		Not enough info to LEARN about the given topics	
9	07_09	"I should wait to see the complete slide. Should be ""provided"" a link to get more information about the topic. Q14_4: like an option should be better"	when I used examples I learnt more	I need extra time after class to complete the e-learning, but it was useful. Where (at university)	I would improve the simulators showing examples.	You should put more examples and show the usefulness of each algorithm, explaining in which case it is more convenient to use one or other.	

10	07_10	On lit que du texte qui pourrait être imprimé sur une feuille pour 0euro. Le quizz peut être fait en classe avec les télécommandes déjà achetées par l'IFP. *(we read text that could be printed on paper, worth 0euros. The quizz can be done in class with clickers, already bought by the school)*	But I would have learn the same with a cheap booklet		improve	si il est cher, il ne faut pas l'acheter à l'heure actuelle *(if it is expensive, don't by it so far)*	
11	07_11				it would be better to be able to download excel file to e-learning in ordert o be checked (correct value or not?)		
12	07_12	Material was very clear, illustrative	Use of variograms and its meaning	It demands time, but about 30mins is something you can handle	give more details and simplier vocabulary		
13	07_13	It´s a good idea to complement the normal classes	That I should read more from other sources	It's not really time consuming	It can begin simplier and then add complexity	Some questions were completely easy to deduce from what was explained	Yes, I would like to keep using it, it is a good idea. I won't write my name anyway.
14	07_14	Very good quality of materials!	The most useful part of e-learning is teacher explanations	It's short and interesting!			X
15	07_15	Well explanation of the topic and very interactive		Not too long and interesting.	more explanation about simulators	Have classes about that before, then reinforce with e-learning and then Questions and Answers	Not too long and interesting.
16	07_16			Not very long.	improve estimators		

17	07_17	It gives you the best way to evaluate yourself by Quizz	Statistical analysis curves				
18	07_18	Can be improved by adding a direct return on the exercise.	Variogram and how to build it. Q14_9: Having Quizz for self-assessment is very important.	because it was not too long (15min approx.) (where: at school)	make do the variogram interactively		
19	07_19						
20	07_20	It was helpful but can not substitute for classroom teaching		other engagements			No
21	07_21	It is nice to learn something at home and then come to class to understand it through a discussion with th teacher.	Basics of Geostatistics	Depends on the situation at home and family	Nothing.	I think the parameters of each equation should be defined clearly for example F=X-mn, so what is m?	
22	07_22	Could possibly recommand further sensitivity analysis to be conducted / reference books to read for further understandin g	Difference between Pixel Based and OBM	I have lots of time and I love to learn everything about Geostatistics, modelling and geology.	Add more scenarios, pros and cons, the advantage of each method in layman's terms. It would be good to provide a basics of statistics in this course (not part of e-learning course but as a reference). Q15_8: Lack of case studies at e-learning moment Q15_2: but explanation given during class is not very satisfactory Q14_12: useful for reference		
23	07_23	Very convenient	methods		more information	no	yes

24	07_24	Well done!	Main concepts			Les exercices Excel devraient comporter une case réponse pour vérifier que l'on a juste (comme le petit exercice en ligne), vert si bon, rouge si faux *(Excel based exercises should be auto-corrected (as the embedded exercises), green if correct, red if not)*	
25	07_25	Interactive	spatial estimations		more information on how are the simulation input data is used to.		
26	07_26	I still prefer humans explaining it					
27	07_27	There isnot enough information.		I can't go fast with the presentation	I need more explanation		
Total N	27	27	27	27	27	27	27
1	08_01						
2	08_02	It helps me understand more than I did	Relation between variogram range and geological settings (channels)	It could be completed at anytime even weekend (where: IFP)	no		
3	08_03	You can't ask ??? Doing e-learning	Types of simulations most interesting	bad internet connection	give the answers for the exercises	It could be nice to get the right answers after finiching the Quizz	
4	08_04	It is very good organized.	Variograms		No, it was well done.		
5	08_05	Helps me understand more in Geostatistics.	Kriging	It doesn't take time	Explain what is the link among variogram, kriging, and simulation (e.g. how kriging links to variogram)		
6	08_06	I liked it but I would have liked to get more details	Many points that were not explained ???.	Available time, already some knowledge about it (at school)		Maybe developing Kriging types	

		for each method especially for kriging: simple, ???	Different types of simulation. Exercises: meaning behind some parameters				
7	08_07	Questions and presentation of the contents on the platform was very clear	Variograms: origin, features, types, uses				
8	08_08		I've already learnt everything during the classroom session.	It has been done after the geostatistical course			
9	08_09	Geostatistic is very important lecture but we need more sessions in order to catch everything. Actually is not easy to manage.	Variograms	I don't have any problems to do it.	Add more time to learn	The questionnaire is too long	yes. X
10	08_10		I practiced what I already know	it was interesting			
11	08_11	It summarizes the most important points	It was good for summary		It was too short compared to the rest	no	no
12	08_12	It was very interactive	the simulation process SGS	because we have plenty of time	Too basic, could have been more advanced	Yes, it is a very interactive e-lerning course, very much recommended	yes, X
13	08_13						
14	08_14	It's great to go at your speed but if you're stuck for exercises you can't ask the teacher.	Maybe details on basics I wouldn't have dared to ask.				
15	08_15	It was well explained and well illustrated. Maybe should be more focused on some definitions	The meaning of each interpolation and simulation methods	(where: at school)	improve because is maybe to difficult to understand. Maybe a full example could be incorporated.		

		(terminology)					
16	08_16	lectures with basics plus nice examples		It is just a matter of organisation	More practical exercise	Very good to have e-learning in parallel	
17	08_17	Short explanations and good exercises	variograms	because it well organized	Instead of only drawing nugget effect, sill and range, I would write a definition and interpretation with real cases		
18	08_18	good major points explained	recognition of different paramters	easy to read			
19	08_19	I find it a very interesting application	It helps me in the understandin g of the variogram		Simulator		
20	08_20	I am not satisfied with the way of teaching. I feel like need to ask some questions.			no		
21	08_21	Because it is everytime better to do it by yourself	Practical application helped me to better understand.	There are some points which I would like to discuss	I would propose to do it before and after Geostatistics teaching unit		X
22	08_22	It's OK, I would be greatful, if you can put the exercises solutions.	I have confirmed all the Geostatistics concepts while doing the exercises attached to the web.	No time during the housday	I will add the solution for each exercise, to be sure that I have did a good job	Please record all the attempt grades and illustrate them in the first page	X
23	08_23	Brief summary of courses and clear small exercises to well understand the theory.	The difference between Geostatistics methods, particularly difference between estimations / simulations	It was after class. E-learning module not too long (20mn). (Frequency of Gestat usage: all depends on the job)	Monte Carlo simulation is well illustratd, it would be nice to explain the other methods with interactive schema (for Kriging or SGS example)		X
24	08_24				add exercises		
Total N	24	24	24	24	24	24	24
1	09_01	Sometimes, exercises are not clearly explained	kriging				

2	09_02	It's a complete tutorial explained in a simple way	mostly about data distribution and variogram	It was in my schedule	none	good job!	X
3	09_03	It is a good review to understand Geostatistics goals and methods	(internship). The different methods of simulation.				
4	09_04	Very clear sessions but a little over my poor level in statistics and Geostatistics	The basics of Geostatistics	You can access the module when ever you want (at home for example9	More basic concepts on statistics and Geostatistics		Yes: X
Total N	4	4	4	4	4	4	4
1	10_01		basic concepts	Because it required only 10-15 minutes	I'd add some exercises to better understand simulators	Some of the exercises (excel docs) were difficult to understand (I would add more/better instructions)	X
2	10_02	Explicado de forma practica y sencilla *(practical and simple explanations)*	Vision general, no profundizaci on *(general vision, not deepened)*	Trabajo y otras obligaciones *(work and other commitments)*			
3	10_03	I have problem with web visualization	I have problem with web visualization	Because job time			X
4	10_04						
5	10_05				I would add the answers of the exercises		
6	10_06	easy to understand, clear and direct	about the variogram	e-learning!		Improve the implementatio n of the e-learning tutorial for Windows 7, etc…	I don't know now.
Total N	6	6	6	6	6	6	6
1	11_01	the exercises didn't work			more general basic explanation for non-statistic people	no	no
2	11_02	Excel exercises did not open due to misplaced username, password boxes	just general idea	current project			

3	11_03	short, precise information and exercises	variograms	other work priorities		limitation are mainly related to it issues in using the module	no
4	11_04	the tool is not so easy to use	get a general introduction of main concepts		not very well explained		
5	11_05	Web page didn't display right. It took me way longer to do it than 40 min. Plus am I not supposed to learn those things at the course?	math	Busy with higher priority business.		I would like e-learning if I don't do the course. Everything in the e-learning course is part of the course. I don't see the need to replicate the same thing with e-learning. It's like squeezing 2 days course into 40 min! Useless if I do the course.	
Total N	5	5	5	5	5	5	5
1	12_01	the instructions were clear	the variogram				no in this moment
2	12_02	Porque permitia pensar bien las respuestas antes de responder y ademas te monstraba los fallos en caso de haberlos *(because it allowed to think before submitting the answers, in addition, it shows the mistakes in case of having some)*	mostraba de forma interactiva los conceptos dados en clases *(interactive way to show the concepts presented in class)*	porque no se habian terminado de dar los conceptos *(because the concepts weren't explained yet)*	promover mas simulaciones *(promote more simulations)*		
3	12_03			porque no requeria mucho tiempo *(because it didn't take too long)*			
4	12_04	muy sencillo de aprobar por las infinitas oportunidade s por la que	no sabia que decir *(didn't know what to tell)*	preguntas sencillas y muchos intentos *(easy assignments and lots of attempts)*		como base esta bien, pero seria interesante que tuviera mas modulos	no gracias *(no, thanks)*

		no se pone mucho empeño en realisar los ejemplos *(very easy to check with unlimited use, it doesn't involve much to complete the examples)*				para aprofondizar aprendizaje *(as a basis, it is good, but it would have been great to have more module to get deeper)*	
5	12_05	Interesante *(interesting)*	Eran cosas que ya habiamos dado *(it was things we already have covered)*	a veces te atascabas pero se podia avanzar *(you could be stuck sometimes, but you could go on)*			
Total N	5	5	5	5	5	5	5
N	78	78	78	78	78	78	78

Appendix 28. Example of the mail sent by the teacher to the students 10 days before class started (course 7).

Dear students,

As it was told last Monday, an e-learning course is scheduled to introduce Geostatistics in the XXX teaching unit.

This e-learning course is made of two parts:
- Track 1 covers the first section “Spatial analysis” and the second section “Spatial correlation” of the e-learning course. Estimated duration: 20 mn.
Track 1 is **to be completed before Tuesday 4 March**. Access will be given to you today, Tuesday 25 February.

- Track 2 covers the third section “Spatial estimations" and the fourth section “Spatial simulations”. Estimated duration: 20 mn.
Track 2 is **to be completed before Thursday 6 March**. Access will be given to you on Monday 3 March.

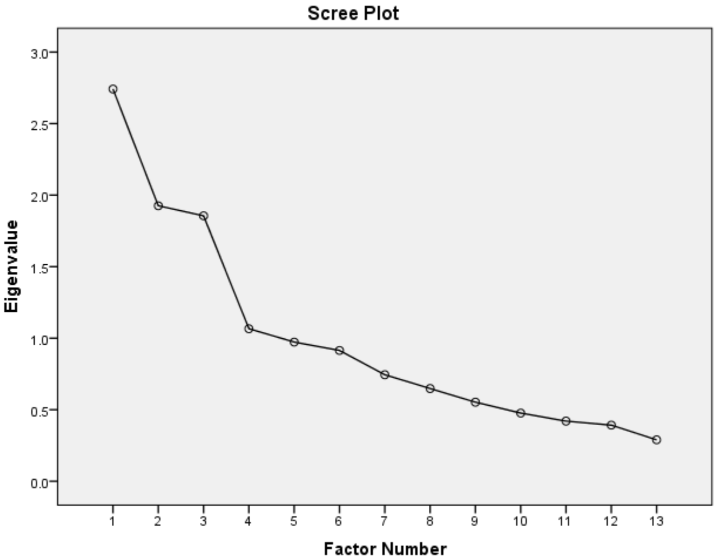
Each track includes exercises and a final Quizz to be validated. Your participation is mandatory as it is part of this teaching unit.
You can benefit from this experience by listing points which are unclear for you. Any question can be discussed in class.

You will receive your ID and password today, in a mail sent by Rémy CREPON who built this module.

Appendix 29. Main elements of the principle axis factor analysis.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.634
Bartlett's Test of Sphericity	Approx. Chi-Square	177.876
	df	78
	Sig.	.000



Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.742	21.092	21.092	2.176	16.735	16.735	1.921	14.773	14.773
2	1.926	14.812	35.903	1.349	10.378	27.114	1.590	12.228	27.001
3	1.855	14.272	50.175	1.240	9.536	36.650	1.254	9.649	36.650
4	1.066	8.202	58.377						
5	.973	7.484	65.861						
6	.914	7.034	72.895						
7	.745	5.727	78.622						
8	.648	4.985	83.608						
9	.553	4.251	87.858						
10	.476	3.665	91.523						
11	.420	3.234	94.757						
12	.392	3.017	97.774						
13	.289	2.226	100.000						

Appendix 30. Tables of the regression weights for the path models relative to factor 1, 2 and 3.

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
Q5	<---	Q7	.548	.091	6.049	***	
Q15_5	<---	Q15_4	.203	.095	2.148	.032	
Q15_5	<---	Q7	.334	.108	3.079	.002	
Q15_5	<---	Q9_62	.163	.076	2.160	.031	
Q14_11	<---	Q5	.495	.167	2.965	.003	

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
Q11	<---	Q2_1	-.490	.138	-3.542	***	
Q14_12	<---	Q14_10	.351	.106	3.324	***	

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
Q14_7	<---	eLearning_expectations	.701	.192	3.657	***	
Q14_1	<---	eLearning_expectations	.292	.097	3.018	.003	
Q14_9	<---	eLearning_expectations	.336	.134	2.510	.012	
Q10_1	<---	engagement_over_Time	.574	.196	2.935	.003	
Q14_12	<---	engagement_over_Time	.687	.193	3.550	***	
Q14_10	<---	engagement_over_Time	.529	.171	3.093	.002	
Q14_11	<---	Learning_awareness	.473	.159	2.981	.003	
Q15_5	<---	Learning_awareness	.474	.114	4.170	***	
Q7	<---	Learning_awareness	.598	.106	5.659	***	
Q5	<---	Learning_awareness	.658	.101	6.495	***	
Q15_4	<---	Learning_awareness	.335	.128	2.628	.009	