An investigation of the relationship between multimedia and instructional design

by

Felicia Pantazi
M.D., Titu Maiorescu University, 1999

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of the Requirements for the Degree of

Master of Science

in Health Information Science

Supervisory Committee

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Dr. Malcolm Maclure, Sc.D., Adjunct Professor, School of Health Information Science, University of Victoria
Co-Supervisor

Dr. Denis Protti, Sc.D.(hon), Professor Emeritus, School of Health Information Science, University of Victoria
Co-Supervisor

Dr. Kate Seaborne, Ed.D., Manager, Distance Education Services, Division of Continuing Studies, University of Victoria
Additional Member

Abstract

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This research aims at exploring the existence of a relationship between the use of multimedia in teaching and instructional design guidelines (IDG). An ontology of types of media and teaching methods was developed. Semi-structured interviews have been conducted with 20 instructors. Qualitative and quantitative methodologies were employed. While these are results from a pilot study with a small sample, the analyses suggests a relationship between the use of media in teaching and IDG that is influenced by years of teaching experience and field of study (i.e., Social Sciences). The instructors' self-assessment of IDG and media usage was not reliable and further validation of a self-assessment instrument is needed. This pilot study demonstrates the feasibility of the methodology which can be used in future research with more participants.

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Dedication

To my husband, Stefan, for his support, advice and love.

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Introduction

In recent decades, the development of information and communication technology has allowed for an unprecedented growth of and rapid access to information. Computer technology and the Internet make multimedia design, development and distribution inexpensive and accessible. These advancements in technology have become extremely valuable for teaching: instructors are using multimedia (e.g., slideshows, video-clips, animated graphics) in their teaching and often replace traditional overhead transparencies and printed materials with electronic resources. However, when planning a lecture, instructors should also consider student learning needs and should develop learning materials (which may include multimedia) in relation to these needs.

Our experience indicates that the use of information technology and of media in teaching must be related in some way to the principles of instructional design. This thesis aims at exploring the relationship between the use of media in teaching and instructional design guidelines (IDG).

The objectives of this thesis are:

1) to assess instructors' use of media in teaching,
2) to assess instructors' awareness of IDG,
3) to explore the possible relationship between media and IDG, and
4) to propose objective measures (i.e., the media amplitude (MA)) that can help characterise the media content of course materials.

Concretely, this work aims at answering a research question that can be formulated as follows: "Is there a correlation between the use of media in course materials and the coverage of instructional design guidelines (IDG)?" In principle, the existence of such a correlation would allow one to:

1. estimate more effectively the coverage of the IDG through a media analysis of course materials,

2. modify the use of media in teaching materials in order to improve the coverage of IDG, and
3. communicate and monitor more effectively and objectively the level of IDG coverage of course materials through quantifiable concepts (e.g., MA).

The rapid advancement of technology and access to information are also important to healthcare. The education of medical and nursing students, healthcare providers, patients and the public could also benefit from research of the use of media in instructional design. The literature shows that the use of media, such as computer-simulations, in teaching medical students and training physicians provides richer context and allows exposure to real life situations (Hoffman, 1997, Cedan, 2007).

Literature also shows that computer-assisted patient education is insufficiently used in office-based settings even though improvement of efficiency was reported (Wafford, 2005). A paediatrics study reports significant knowledge improvement for children with asthma after supplementing conventional asthma care with interactive multimedia education (Krishna, 2003). However, teaching a heterogeneous patient population with different characteristics (e.g., background, age) that influence the way they learn is not generally an easy task.

This research hinges on the assumption that properly designed instructional materials (e.g., those that follow IDG) should aim to convey messages and their meaning to all kinds of learners. A defining aspect of this work is an investigation of the use of media that may offer solutions to instructional design approaches.

The thesis is structured as follows. Chapter 1 provides a background that includes an instructional design introduction, a literature review of the use of media in teaching and theories and models used in instructional design. Chapter 2 provides a review of the human sensory receptors and how the brain processes information which forms the basis of a media ontology. Also the concept of MA is defined and discussed in this chapter. Chapter 3 describes the methods and approaches used in this study and chapter 4 reports the results. The final chapter discusses the results and the study limitations.

1. Literature Review

In this chapter, the notion of instructional design will be defined and a review of the literature on the use of media in teaching will be presented, including a selection of some of the theories and models that explore the use of media in teaching and learning.

1.1. Instructional design

Instructional design theory was established by many prominent people in the field of education and/or psychology and, as a result, a wide variety of definitions are available in the literature. This section introduces some of the definitions that support the instructional design guidelines (IDG) adopted in this research.

According to Reigeluth (Reigeluth, 1999, p. 7), "instructional design is concerned with understanding, improving, and applying methods of instruction". Robert Gagné, one of the pioneers of instructional design during the World War II, defines instruction as "[…] a set of events external to the learner designed to support the internal process of learning" (Gagné et al., 2005, p. 194). One of his most important contributions to the field is represented by the nine-step process called "The Nine Events of Instruction" which "[…] are designed to activate the process of information processing, or at least to parallel their occurrence, and support the process" [of learning] (Table 1) (Gagné et al., 2005, p. 194).

Nine Events of Instruction
1. Gain attention of learner
2. Inform learner of objective
3. Stimulate recall of prerequisites
4. Preset stimulus material
5. Provide learning guidance
6. Elicit performance
7. Provide feedback
8. Assess performance
9. Enhance retention and transfer

Table 1. Gagné's Nine Events of Instruction (Gagné et al., 2005, p. 195)

In addition to the instructional design guidance provided by the “Nine Events of Instruction”, Gagné also suggests listing possible media for each of the nine events during the lesson planning phase.

A selection of instructional design theories and models will be discussed in the Theories and Models section of this chapter. For the purpose of this research, a list of instructional design guidelines (IDG) has been created. The adopted IDG framework is based on Gagne’s Nine Events of Instruction and on the approach used by the Distance Education Services, Division of Continuing Studies at University of Victoria. According to this IDG framework, ideally, the instructional materials in a course:

A) address one or more of the course’s intended learning outcomes,
B) help the learner build mental models to assist developing deeper understanding,
C) support the development of critical thinking skill,
D) promote the learners' active engagement and ongoing interaction with the content, the instructor, other learners,
E) build on the learner’s prior knowledge of the content,
F) capture the learners' attention and stimulates interest,
G) support the transfer of learning to applied or personal contexts.

1.2. The use of media in teaching – a literature review

This section reviews the literature on the use of media in teaching, including definitions, classifications and methods of selecting media. A careful and necessary distinction will be made between terms such as ‘media’, ‘multimedia’, ‘delivery methods’, and ‘teaching methods’.

1.2.1. Brief history

The use of various types of media in teaching can be traced back to early 1900’s. In 1905, the first School Museum opened in St. Louis (Reiser, 2001). The museum was a collection of instructional media such as portable museum exhibits, slides, films, study prints, etc. They were referred to as “visual media”, “visual education” or “visual instruction”. Reiser (Reiser, 2001) cites Saettler (Saettler, 1990) in his mentioning of the Visual Instruction Movement and the use of Instructional Films media that has started in

the same period of time. Reiser (Reiser, 2001) also notes Anderson's (Anderson, 1962) references to the "magic lanterns" (lantern slide projectors) and "stereopticons" (stereograph viewers) that were used in schools since the second half of 19th century and followed very soon by the motion picture projector. In 1910 the first catalogue of instructional films was published in the United States.

During the 1920's - 1930's, with the development of radio broadcasts, sound motion pictures and sound recordings, the term "audiovisual instruction" was first introduced. Ely and Plomp (Ely and Plomp, 1996) document some of the earliest academic publications on the use of media in teaching by Wood and Freeman at University of Chicago and Knowlton and Tilton at Columbia University, in 1929. Freeman's article "A scientific study of visual education" is also notable in this context in that it precedes the works referred to by Ely and Plomp (Freeman, 1924). Various textbooks on the topic of visual instruction were published, one of the most important ones being "Visualizing the Curriculum" by Hoban (Hoban et al., 1937, p. 39). Hoban appears to be the very first who created a hierarchical organization of media based on their concreteness-abstraction order. This is of importance to this thesis and will be revisited in the Instructional Design and Media Selection section.

During the World War II (WWII), the US Army Air Force created more than 400 films and 600 filmstrips in a two-year period with the purpose of training military personnel. The United States federal government established the Division of Visual Aids for War Training responsible for creating over 400 films for civilians to be trained to work in the industry during WWII (Reiser, 2001).

During the 1950's, television very rapidly became an instructional medium. The Federal Communications Commission, the United States agency generally responsible for communications by radio, television, wire, satellite and cable and, in particular, with the allocation and use of radio frequency bands, had set aside 242 TV channels for educational purposes. During the 1950's – 1960's, computer-assisted instruction (CAI) was introduced in schools and universities. During this time the term "audiovisual instruction" started to be replaced by terms such as "educational technology" and "instructional technology".

Throughout the twentieth century, technological developments have deeply influenced instruction and have caused terminology to evolve. While in the 1920's the term 'mass media' referred only to newspapers, magazines and radio, throughout the past 80 years its meaning has changed to reflect the new technological developments and their use for instructional purposes.

1.2.2. Definitions

Gagné and Briggs (Gagné & Briggs, 1979, p. 175) define media as "the physical means of communication (books, printed modules, programmed texts; computers; slide/tape presentations; films, videotapes, and so on)".

Romiszowski (Romiszowski, 1988, pp. 7, 8) defines media as "the carriers of messages, from some transmitting source (which may be a human being or an inanimate object) to the receiver of the message (which in our case is the learner)". He also defines the message as "the information which is being transmitted".

During the 1970's the term *instructional media* emerged and since then it has been interchangeably used with the term *media*. Instructional media is defined by Reiser (Reiser & Gagné, 1983) as "the physical means by which an instruction message is communicated." In 2005 Gagné (Gagné et al., 2005, p. 228) also defines instructional media as a "[…] variety of ways instruction can be communicated, such as audio, video and film, text, photographs, animation, and graphics". Similarly, Heinich (Heinich et al., 1993, p. 4) considers instructional media to be the media that carry messages with an instructional purpose.

The term *multimedia* emerged in the 1990's. Mayer defines it in reference to the use of words (written or spoken text) and pictures (photos, illustrations, animation, or video) in instruction. He considers multimedia instruction as "[…] the presentation of words and pictures with the intent of promoting learning."(Mayer, 2005, pg. 2)

Table 2 contains some examples of the term "media" listed in chronological order. Despite some variation due to advances in technology, the concept of media appears to have remained consistent throughout the years. For example, in 1937, Hoban defined media as words, diagrams, pictures, film, objects, etc. More than a half a century later, in 2005 Gagné's considers media being audio, video, film, text, photographs, animation, and graphics. Interestingly, Laurillard (Laurillarad, 2002, p. 89) categorized media based on the teaching strategy:

- **narrative media:** lecture, print, audiovision, television, video, dvd,
- **interactive media:** hypermedia, enhanced hypermedia, web resources, interactive television,
- **adaptive media:** simulations, virtual environments, tutorial programs, tutorial simulations, educational games,
- **communicative media:** computer-mediated conferencing, digital document discussion environment, audio conferencing, video conferencing, student collaboration and
- **productive media:** microworlds, collaborative microworlds, modeling.

Author	**Media**
Hoban (1937)	objects, models, films, stereographs, slides, flat pictures, maps, diagrams and words
Gagné & Briggs (1979, p. 175)	books, printed modules, programmed texts; computers; slide/tape presentations; films, videotapes, etc.
Rowntree (1990, pp. 73-74)	print, audio visual, practical work, human interaction
Laurillard (2002)	media categories: narrative, interactive, adaptive, communicative and productive
Gagné (Gagné et al., 2005, pp. 226, 228)	audio, video, film, text, photographs, animation, and graphics Multimedia is "[…] a combination of these media".

Table 2. Media types by author

According to Romiszowski (Romiszowski, 1988, pp. 7, 8), the concept of media should be narrow enough to include only the media that is effectively used in teaching but broad enough "to include not only complex electronic communication media but also simpler devices such as slides, photographs, teacher-made diagrams and charts".

Another view on the concept was formulated in 1964 by Marshall McLuhan who wrote that "the medium is the message" (McLuhan, 1964, pp. 7-8). According to this view, if one sent a dinner invitation via three different methods (e.g., hand written invitation, phone call and email), "[…] one should consider the elocutionary effect of the message to be different each time."[1] While it is true that the message could have a variety of interpretations by people with different backgrounds, ages and cultures (an older person might find the email invitation less considerate than a written one), the view appears rather extreme: the choice of medium cannot be the only influence on the message. At least one significant part of the message would be consistent across alternative interpretations: the planned location and time of the dinner. While the choice of media may have an influence on the learning process, the messages cannot be completely distorted. This is supported by Ely and Plomp (Ely and Plomp, 1996) citing Clark (Clark, 1983) whose opinion is that the way media is used, not the media itself, influences the effectiveness of learning. Through their choice of the word "influences" in his statement "the medium influences the message and the message influences the medium", Dale (Dale, 1969, p. 133) also appears to be in agreement with Clark.

Many authors give examples of media but few distinguish it explicitly from the teaching methods that employ that media. For example, Rowntree believes print to be a type of media while Laurillard believes it to be a teaching method. It is often very difficult to understand the criteria that some authors used to separate the notion of media from the teaching methods even though the terms may have been separately defined.

Heinich (Heinich et al., 1993, pp. 5-9) considers that teaching methods "[…] are the procedures of instruction that are selected to help learners achieve the objectives or to

[1] Example based on a discussion with Dr. Rick Mitchell, Ed.D., Technical Communications Professor and Pathways Coordinator at Conestoga College, Ontario

internalize the content or message". He categorizes teaching methods in 9 categories: presentation, demonstration, discussion, drill-and-practice, tutorial, cooperative learning, gaming, simulation, discovery, problem solving.

Laurillard (Laurillard, 2002, p. 89) also makes the distinction between the media and delivery methods: "The media of text, talks, visual, or interaction can be delivered via meetings, print, cassette, disc, or link to a network".

While most authors address only the teaching methods, Gagné (Gagné et al., 2005, pp. 226, 228) refines these notions a step further and makes a clear distinction between *teaching methods* and *delivery methods*. The delivery methods "[…] are the actual mechanisms for delivering instructions" while the teaching methods "[…] are tools or techniques […] for designing and facilitating learning". For example he considers classroom teaching, video conferencing, computer-based training, handheld computer/PDA to be delivery methods. Similar to Heinich's categories, Gagné's teaching methods are focus group/forum, group discussion, collaborative learning, self-directed/discovery learning, mentoring, demonstration, lecture/tutorial, simulation, practice, etc.

Gagné and Briggs (Gagné & Briggs, 1979, p. 175) recognize that the term media is not entirely standardized. Therefore, they proceed to define additional, more fundamental terms that are in close relationship, such as sensory mode, channel of communication and type of stimulus. The *sensory mode* is represented by "the sense organ stimulated by an instructional message (the eye, the ear, and so on)" while the *channel of communication* is "the sensory mode used in a communication (visual, auditory, tactile, kinaesthetic, olfactory, and so on)". The type of stimulus is represented by "the means but not the mechanism of communication" (e.g. the spoken word, the printed word, motion pictures, etc.). Rowntree (Rowntree, 1990, pp. 73-74) also defines the *types of stimuli* being the written word, pictures, recorded sound, human interaction, and real objects and events.

Many of the definitions presented earlier aimed at representing similar concepts ("media", "multimedia", "multimedia instruction" and "instructional media"). However,

the existing conceptual variations and the need to improve and maintain consistency within this research require explicit distinctions between the following:

- Teaching methods: "[…] the procedures of instruction that are selected to help learners achieve the objectives or to internalize the content or message". (Heinich et al., 1993, p. 5)
- Type of stimuli - spoken words, still pictures, objects, motion pictures (Briggs, 1970, 1977, Briggs et al., 1979, Rowntree, 1990)
- Medium (plural media) is "[…] the physical means of communication (books, printed modules, programmed texts; computers; slide/tape presentations; films, videotapes, and so on)" (Gagné & Briggs, 1979, p. 175)
- Instructional media: media that carry messages with an instructional purpose (Heinich et al., 1993, p. 4)
- Message:
  - "the information which is being transmitted" (Romiszowski, 1988, p. 9).
  - "[…] usually subject-matter content" (Heinich et al., 1993, p. 5).
  - Can be from instructor to learner and from learner to instructor.
- Sense organs acted upon (e.g., eye, ear)
- Sensory channel / channel of communication: "the sensory mode used in a communication (visual, auditory, tactile, kinaesthetic, olfactory, and so on)" (Gagné & Briggs, 1979, p. 175)
- Equipment – necessary for some of the media (e.g. overhead projector) (Briggs, 1977)

This need for concept refinement and for distinguishing between closely related terms will become more evident in the next chapter, where the terms will be employed in the development of a model of the "instruction process".

1.2.3. Instructional Design and Media Selection

The connections between instructional media and the systematic process of instructional design, as defined earlier, are evident. Gagné suggests that lesson planning (an instructional design method) should include four elements (Gagné et al., 2005, p. 248):

1. a statement of the lesson's objective and its classification in terms of the domain of learning (e.g. verbal information, attitude, intellectual skill, etc.),
2. the list of the Nine Events of Instruction (shown in Table 1),
3. a list of media, materials and activities for each event, and
4. a set of notes on instructor activities for each event (i.e., instructional treatment or strategy).

The suggestion of creating a list of media in relation to activities for each instructional event suggests that the selection of media is not random. On the contrary, one should follow a systematic approach that may need to consider many factors such as sociological, logistical, psychological and economic (Gagné et al., 2005, p. 230). Also accessibility to media has to be considered. However, this thesis does not aim at exploring the methods of selecting media. What is of importance to this research is the relationship between selected media and the teaching methods adopted by instructors as part of their instructional events. In order to better understand this connection with delivery methods and activities, an exploration of various types of media, as they are described in literature, is needed.

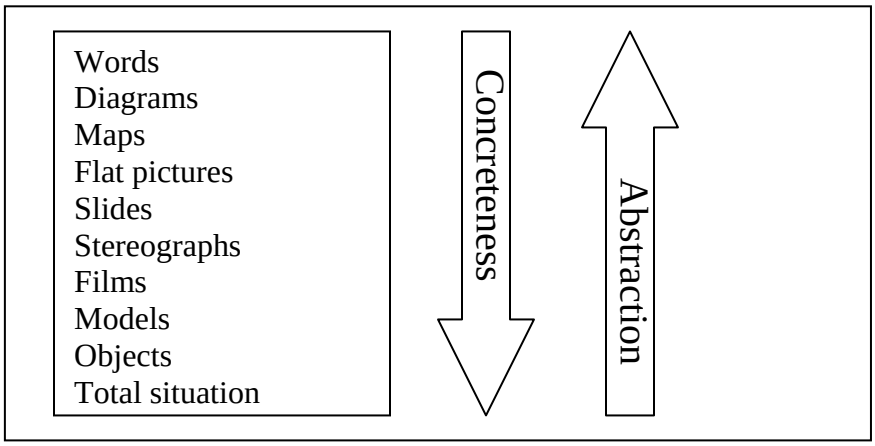

Figure 1. Hoban's categorization of media (adaptation)

One of the earliest categorizations of media was introduced by Charles F. Hoban, Sr. (Hoban et al., 1937, p. 39). Media was arranged based on their concreteness: total situation (being the most concrete), objects, models, films, stereographs, slides, flat

pictures, maps, diagrams, and words (the most abstract) (Figure 1). The concreteness of media increases from words to total situation while the abstraction decreases (and vice versa).

Charles F. Hoban, Sr. Edgar Dale

Pictures used with permission from the Association for Educational Communications and Technology (http://www.aect.org)

Figure 2. Charles F. Hoban, Sr. and Edgar Dale

Almost 10 years later, in 1946, Edgar Dale published the "Cone of Experience" (Dale, 1969, p. 107). Dale's cone is similar by organizing the media on a concreteness-abstraction scale. The cone is a visual representation of media that shows the progression from reality (at the bottom) to abstract (at the top) (Figure 3).

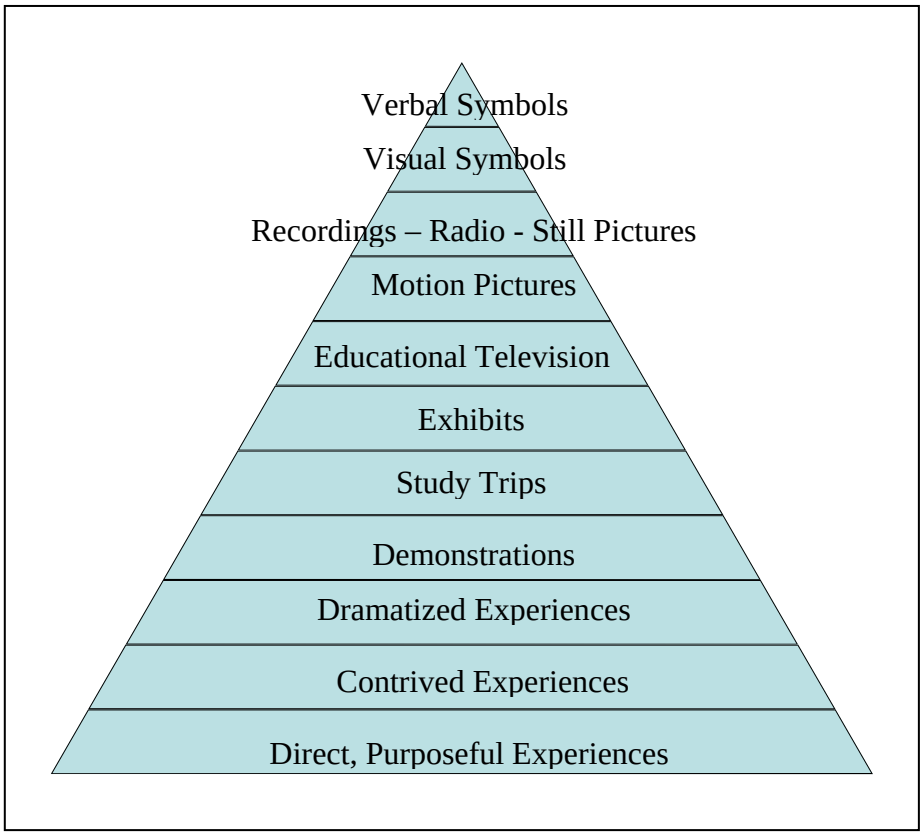

Figure 3. Dale's Cone of Experience (adaptation)

The original categories have been only slightly modified in later editions of the book as shown in Table 3, proving the concept has remained fairly stable in time. The later edition includes new types of media that have been arising in the 20 years period (1949-1969) and they are highlighted in Table 3.

First edition (1949)	**Third edition (1969)**
Verbal Symbols	Verbal Symbols
Visual Symbols	Visual Symbols
Radio – Recordings – Still Pictures	Recordings – Radio - Still Pictures
Motion Pictures	Motion Pictures
	Educational Television
Exhibits	Exhibits
Field Trips	Study Trips
Demonstrations	Demonstrations
Dramatic Participation	Dramatized Experiences
Contrived Experiences	Contrived Experiences
Direct, Purposeful Experiences	Direct, Purposeful Experiences

Table 3. Dale's Cone of Experience categories

Despite being such an early model, Dale's Cone of Experience remains a powerful and useful concept for organizing media which has been adopted by others for the purpose of selecting instructional media. It could also be used to support a notion of *learning efficiency* that could be defined by the extent in time and space of the instructional events or teaching methods employed. For example, Gagné and Briggs suggest to "go as low on the scale as you need in order to ensure learning for your group, but go as high as you can for the most efficient learning" (Gagné & Briggs, 1979, p. 181). In other words, at the extreme, use the "Direct, Purposeful Experiences" to ensure learning, but go as abstract as possible (e.g., very abstract mathematical symbols) in order to achieve the most efficient learning. On the other hand, Gagné & Briggs' suggestion remains somewhat ambiguous. Clearly the authors imply that direct purposeful experiences are easily understood by most of the learners because many can relate to them. However, going as high as one can towards abstractions to ensure most efficient learning may be misinterpreted too strictly as a suggestion to pick and stick to using only one type of media that is located as close to the top of the cone as possible. This is different from the situation where "going as high as one can for the most efficient learning" implies going *through* a variety of media types in their increasing order of abstraction. The latter is more in agreement with Dale's own view that efficient learning implies using the most appropriate teaching methods in accordance with the learner's needs and capabilities at a specific moment in time.

The cone itself is an abstract representation that is very distant from "Direct, Purposeful Experiences". Therefore, it cannot capture and encode all the knowledge necessary to completely construe its meaning. The particular shape is a cone because most of the time the learning begins at the wide base of direct experiences and gradually moves to higher level, abstract concepts. The cone shape does not depict the level of difficulty of learning but the degree of abstraction. In addition, Dale's advice was not to see the categories as "rigid, inflexible" divisions (Dale, 1969, p. 110) and that the classification should not be seen as "rank-order" (Dale, 1969, p. 128)." He insisted that these were methods of teaching and that they should be used whenever appropriate in order to reach the learner. In addition, he advocated the combination of abstract and

concrete experiences: “We do not use any one medium of communication in isolation. Rather, we use many instructional materials to help the student conceptualize his experience so that he can deal with it effectively” (Dale, 1969, p. 133). This appears to support the idea of variation of the types of media.

Completely unaware of Dale’s Cone of Experience, Pantazi (Pantazi et al., 2004) proposed a similar model that he referred to as “the knowledge spectrum”. In his view, “the knowledge spectrum spans from a complex reality (the source of experiential knowledge, experimental data and information gathered from experiences, observations and measurements) to high-level abstractions (e.g., theories, hypotheses, beliefs, concepts, formulae).” One purpose of the knowledge spectrum was to connect media to the processing capabilities of current information and communication technology (Figure 4) and to characterize their potential and limitations for health informatics applications.

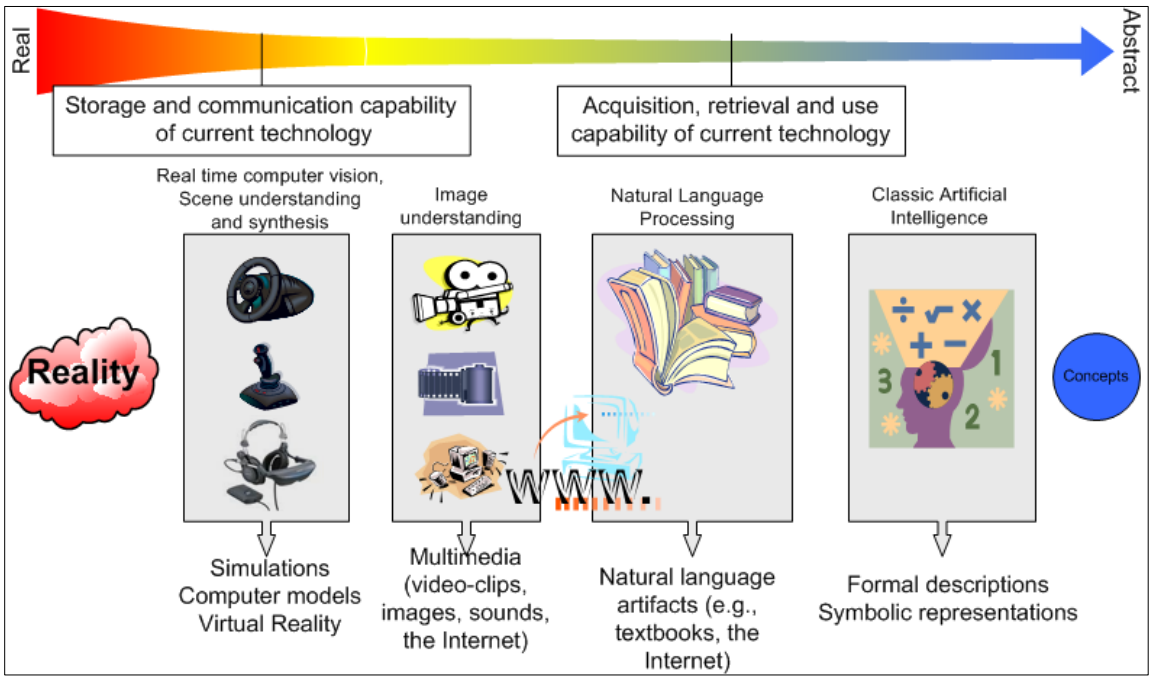

Figure 4. The knowledge spectrum (Pantazi, 2004, used with permission)

Recent experiences with undergraduate level teaching (Pantazi et. al., 2011), suggest that effective teaching may in fact require moving through the knowledge spectrum from reality to abstract and vice-versa as many times as possible during the limited lifetime of

a course. This is in agreement with Dale's suggestions that the use of various types of media improves learning experiences and results in better information retention.

This literature review reveals various ways of classifying media and delivery methods and supports well the distinct nature of the two notions. It has also uncovered a potentially important notion, that of learning efficiency which is intimately connected to fundamental physical concepts (time and space). Most importantly, it supports the idea that the use of a variety of media types and delivery methods influences the instructional process which, indirectly, may be important to instructional design.

1.3. Theories and models

The role of media in teaching has theoretical foundations. This section reviews some of the most well-known instructional design theories and models and also those supporting the idea that the use of media enhances the learning experience.

An instructional design theory is a goal oriented theory that provides guidance. Reigeluth defines instructional design theory as "a theory that offers explicit guidance on how to better help people learn and develop" (Reigeluth, 1999).

Many learning theories and models were borrowed from philosophy and psychology. The main philosophical paradigms are objectivism and constructivism. Objectivists believe there is "one *true* and *correct* reality" (Vrasidas, 2000) therefore the objective knowledge needs to be transferred to the learner's head through the process of instruction. On the other hand, constructivists regard learning as a constructive process where the learner creates his own mental representations of the reality. Constructivism is more concerned with how learners learn than what they learn. Some prominent constructivists are: L. Vygotsky, J. Piaget, J. Bruner, J. Dewey, and M. D. Merrill.

Behaviourism, social theory, cognitivism and developmental theory are some of the paradigms borrowed from psychology:

- **Behaviourism** is a theory that can be traced back to Aristotle. The central idea of behaviourism is that the change of behaviour is caused by external stimuli (principle of stimuli-response). The learner is only answering to the external stimuli and his behaviour is learned from the environment through positive or negative reinforcement. Some prominent behaviourists are: E. L. Thorndike, I. Pavlov, J. B. Watson, and B. F. Skinner.
- **Cognitivism** is a theory that regards the learner as information processor. Opposed to behaviourism, cognitivism considers the learner processing the information not only responding to it. Learning is established through contiguity and repetition. Some prominent cognitivists are: M. D. Merrill, C. M. Reigeluth, L. Briggs, K. Koffka, W. Kohler, and R. M. Gagné.
- **Humanism** considers learning as a learner-centered and personalized process in which the instructor is only a facilitator. The learning process is concerned with the affective and cognitive needs of the learner. Some important humanists are: A. Maslow, C. Rogers, and M. Knowles.
- **Social and situational** theory regards learning as being the process occurring between learners and the environments. The learning process is represented by interaction and observation of social context. Important names in this discipline are: A. Bandura, J. Lave, and E. Wenger.

An instructional model provides the framework that can be used to plan and provide instruction. Some of the known models are shown in Table 4: ADDIE model, Merrill's First Principles of Instruction, Kemp's Instructional Design Model, Gagné's Nine Events of Instruction, Bloom's Learning Taxonomy, Kirkpatrick's 4 Levels of Training Evaluation, Dale’s Cone of Experience, and Bridge - Objective - Pre-test - Participatory learning - Post-test - Summary (BOPPPS).

The ADDIE model (Analysis, Design, Development, Implementation and Evaluation) is a generic process used in instructional design developed at Florida State University in 1975. Based on this model, instructional design consists of the analysis of learning needs and goals and of the development of an appropriate delivery method to meet those needs

and goals. It also includes the development of instructional materials and activities, and the evaluation of the effectiveness of the content and delivery methods to assess whether or not the learning needs and goals are being met.

In the objectivism and behaviourism paradigms several taxonomies of educational objectives were developed. The most well-known taxonomy is Bloom's taxonomy of learning domains (cognitive, affective and psycho-motor) created in 1956. The taxonomy of the cognitive domain categorizes the intellectual skills on a six level framework listed from simplest (recall and recognition of simple facts) to the most complex (synthesis and evaluation).

In 1972 Gagné developed a taxonomy called Gagné's Taxonomy of Learning which comprises five types of learning capabilities: verbal information, intellectual skill, cognitive strategy, attitude, and motor skill. Some of these models are listed in Table 4.

Model	**Categories**	**Paradigm**
ADDIE model (Florida State University, 1975)	1) **A**nalysis, 2) **D**esign, 3) **D**evelopment, 4) **I**mplementation 5) **E**valuation	objectivism
Bloom's Learning Taxonomy of Cognitive Domain (Bloom, 1956)	1) Knowledge, 2) Comprehension, 3) Application, 4) Analysis, 5) Synthesis, 6) Evaluation	objectivism
Bridge – Objective - Pre-test - Participatory learning - Post-test - Summary (BOPPPS)	1) **B**ridge, 2) **O**bjective, 3) **P**re-test, 4) **P**articipatory learning, 5) **P**ost-test, 6) **S**ummary	objectivism

Dale's Cone of Experience	1) Verbal Symbols 2) Visual Symbols 3) Recordings – Radio - Still Pictures 4) Motion Pictures 5) Educational Television 6) Exhibits 7) Study Trips 8) Demonstrations 9) Dramatized Experiences 10) Contrived Experiences 11) Direct, Purposeful Experiences	constructivism
Gagné's Taxonomy of Learning (Gagné, 1972)	1) Verbal information, 2) Intellectual skill, 3) Cognitive strategy, 4) Attitude, 5) Motor skill	cognitivism
Gagné's Nine Events of Instruction	1) Gain attention 2) Inform learner of objectives 3) Stimulate recall of prior learning 4) Present stimulus material 5) Provide learner guidance 6) Elicit performance 7) Provide feedback 8) Assess performance 9) Enhance retention transfer	objectivism
Merrill's First Principles of Instruction (Merrill, 2002)	1) Problem-centered 2) Activation of prior experience 3) Demonstration of skills 4) Application of skills 5) Integration or these skills into real world activities	constructivism
Kemp's Instructional Design Model (Kemp, 1994)	1) Instructional problems, 2) Learner characteristics task analysis, 3) Instructional objectives, 4) Content sequencing, 5) Instructional strategies, 6) Instructional message, 7) Instructional delivery, 8) Evaluation instruments	
Kirkpatrick's 4 Levels of Training Evaluation (1994)	1) Reactions 2) Learning 3) Transfer 4) Results	

Table 4. Instructional Design Models

Some other models that support the idea that the use of media improves the learning experience are: Paivio's dual-coding theory, Sweller's cognitive load theory and Mayer's cognitive theory of multimedia learning (CTML).

Mayer (Mayer, 2001) describes Paivio's dual-coding theory postulating that humans possess two channels for processing information: one for auditory/verbal information and one for visual/pictorial information. It is suggested that this duality leads to the creation of separate representations for information processed in each channel by the human mind. The evidence of two separate channels for processing information also comes from the field of cognitive psychology. Its important implication for this research is that, in order to cover both channels, an instructor should develop at least two distinct types of instructional media.

Gagné (Gagné et al., 2005, p. 228) quotes Hall (Hall, 1995) on his finding that the use of multimedia in training programs improved the retention by as much as 50 percent. The explanation offered for this result is based on Paivio's dual-channel theory.

Also based on Paivio's dual-coding theory and constructive cognitive psychology, Mayer (Mayer, 2001) developed his cognitive theory of multimedia learning (CTML). Interestingly, Mayer's theory does have empirical foundations. His research findings led to the development of the "multimedia principle" which states that "people learn *better* from words and pictures than from words alone." Mayer recognizes that the CTML is based on the following theories:

- Paivio's Dual-channel theory,
- Baddeley's Model of working memory,
- Atkinson & Shiffrin's Multi-store model and
- Sweller's Cognitive load theory.

CTML aims "to represent the human information-processing system" (Mayer, 2005, p.37) where words and pictures are entering the sensory memory through the eyes and ears. This is the first memory store where they are kept for a short period of time as exact

visual and auditory images. The next memory store is represented by the working memory where information is temporarily kept and manipulated in the active consciousness. From there, information is stored in the long term memory.

Based on this theory, Mayer (Mayer, 2005) restated the multimedia principle: “people learn *more deeply* from words and pictures than from words alone”. Mayer considers that instructors should design multimedia presentations in order to help students building mental representations and that these presentations should be designed according to the way human mind works. He also acknowledges that “Not all the pictures are equally effective” (Mayer, 2005, p. 5) and that a research-based approach is needed to understand how people learn from words and pictures. Mayer defines multimedia learning as being the learning process where students build mental representations from words and pictures. According to him, there are two types of multimedia learning approaches: technology centered and learner centered. The first focuses on technology while the learner centered approach focuses on how to adapt technology to enhance learning. In the later case the technology is an aid to human cognition. Interestingly, an identical distinction (technology-centered vs. user-centered) appears to pervade informatics-based approaches to solving problems in healthcare.

Although there are a multitude of instructional design theories and models, a unified set of IDG could not be found in the literature. This determined the creation of the IDG list which was later used in the study for assessing instructors’ awareness and use of instructional design in teaching.

In summary, while there is agreement that media should be selected carefully, many existing theories and models seem to support the general idea that people learn better when a variety of media are used in teaching.

1.4. Media accessibility for people with disabilities

Reigeluth (Reigeluth, 1999) recommends that in addition to selecting media for each instructional event, designers should also be concerned with or take into consideration

various characteristics of learners such as age, experience, and capability of learning from different kinds of media. An important category of learners is represented by the people with disabilities. A survey conducted by Statistics Canada in 2007 (Statistics Canada, 2007) shows that approximately 4.4 million Canadians (representing 14.3% of the population) reported having a disability. The percentage of people with disabilities increased with age from a 3.7% for those between the ages 0-14, up to 56.3% for those 75+ years old.

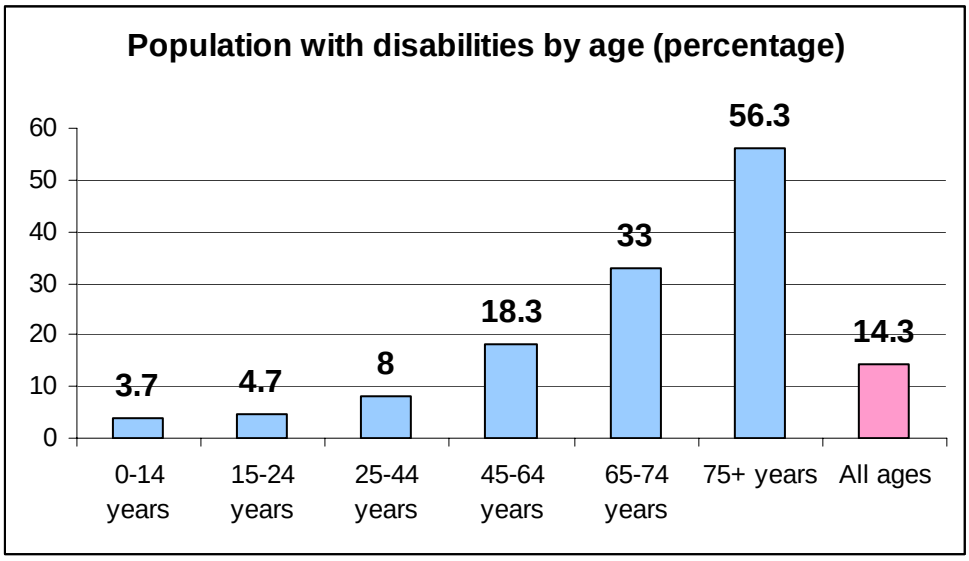

Figure 5. Population with disabilities by age

Among the various ways to categorize disabilities, a good resource with relevance to health informatics is the International Classification of Functioning, Disability and Health (ICF) created by the World Health Organization (WHO). ICF is a classification of health and health-related domains that helps measuring health and disability at a population and individual level. Although ICF is of great value in classifying the functioning and disability level of a population and individual, it is preferable to use the list of disabilities as defined by Industry Canada (Industry Canada, 2011) because of its focus on disabilities types (Table 5).

Disability Category	**Description**
Cognitive Impairment	• Cognitive impairment – affects the ability to think, concentrate, reason, etc. • Intellectual impairment – affects the comprehension

	and information processing
Deaf-Blind	Affects sensory, visual and hearing perception, in combination with each other
Dexterity Impairment (Arms/Hands/Fingers)	Affects the function of arms, hands or fingers
Elderly	Slower learning new skills, memorization difficulties, slower reacting response to instructions
Hearing Impairment	Affects hearing
Learning Disability	Problems in perceiving, understanding and/or using of concepts through verbal or non verbal language or means (e.g., attention deficit, inattention, hyperactivity, impulsivity, dyscalculia, dysgraphia, dyslexia
Mobility Impairment	Reduced function of legs and feet
Speech and Language Impairment	Speech impairment may influence speech in a general way or only certain aspects of it, such as fluency or voice volume. Language impairment may be associated with a more general intellectual impairment
Visual Impairment	Problems with the ability to perceive form (e.g. blindness, colour blindness, low vision)

Table 5. Disability categories

Moisey (Moisey, 2004) reports that 604 students with disabilities (representing 1.5% of the total student population) were enrolled in undergraduate programs at Athabasca University during a 3 year period. The highest percentage of these students had physical disabilities (52.3) followed by learning disabilities (20.5) and psychological disabilities (19.7). The lowest proportions were those with visual impairment (4.1%) and hearing impairment (3%) (Figure 6).

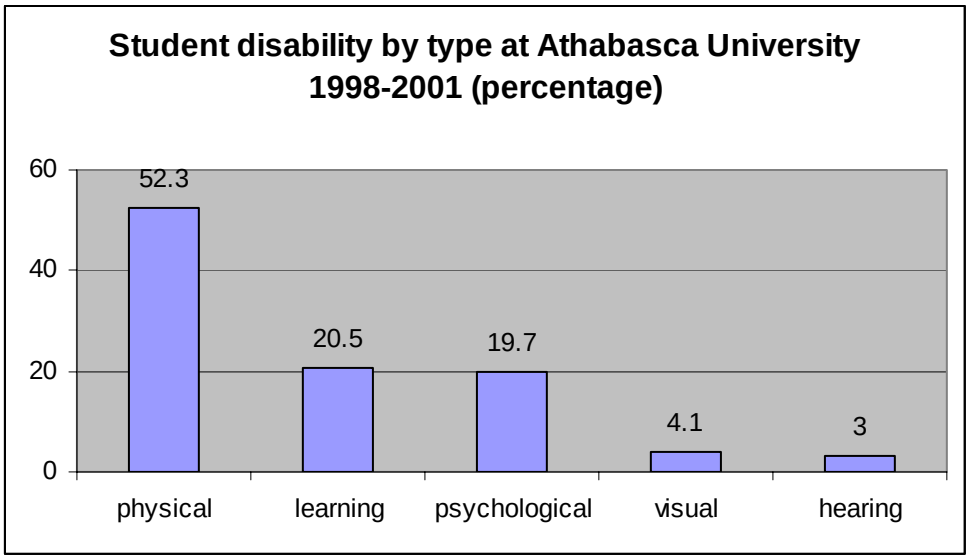

Figure 6. Student disability at Athabasca University 1998-2001, by type

The literature shows that there is a significant population with disabilities whose needs must be considered. Thus course materials, especially for distance courses should be made available for everyone (with or without disabilities) and their accessibility on the World Wide Web has to be taken into consideration when designing a course (Burgstahler et al., 2004). Universal design of instruction is defined as "[…] the design of instruction to be usable by all students, without the need for adaptation or specialized design" (Burgstahler, n.d.) and consists of seven principles: equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort, and size and space for approach and use. These principles mean to direct the designing of courses that are accessible to people with disabilities and, at the same time, to minimize the need of special accommodations.

Properly designed courses that follow instructional design principles and use appropriate media should be developed. For example, if a video is used as part of a teaching method, then the closed captioning feature should be available for those who are hearing impaired. As shown in the Theories and Models section, it is good to take a learner centered approach into consideration when selecting media. Learners' characteristics such as their knowledge of the subject, their age and disabilities, allow instructors to use media that was specifically tailored for those needs.

1.5. IDG framework development

As mentioned at the beginning of this chapter, the adopted IDG framework is based on the literature review and an approach used at the University of Victoria. It was found that the framework is consistent with the literature findings. For example, five of Gagné's Nine Events of Instruction (events 1, 2, 3 and 9) are covered by the chosen IDG (rules A, D, E, F and G) (Table 6). Also the IDG includes intellectual and cognitive aspects of learning (e.g., building mental models, development of critical thinking skill) which are also supported by the literature (e.g., Gagne's Taxonomy of Learning). The adopted IDG is a combination of various educational models and paradigms (i.e., cognitivism, objectivism, and constructivism).

Nine events of instruction (Gagné)	IDG
1. Gain attention of learner 2. Inform learner of objective 3. Stimulate recall of prerequisites 4. Preset stimulus material and 5. Provide learning guidance 6. Elicit performance 7. Provide feedback 8. Assess performance 9. Enhance retention and transfer	A) Address one or more of the course's intended learning outcomes B) Help the learner build mental models to assist developing deeper understanding C) Support the development of critical thinking skill D) Promote the learners' active engagement and ongoing interaction with the content, the instructor, other learners E) Build on the learner's prior knowledge of the content F) Capture the learners' attention and stimulates interest G) Support the transfer of learning to applied or personal contexts.

Table 6. IDG and Gagné's Nine Events of Instruction

The reality of the research methodology (data collection and analysis), which was subject to time constraints (e.g., limited interview time, limited data granularity), has called for a simplification of the original (ideal) IDG rule list. The shorter IDG is therefore aimed more directly at determining whether the use of media in course materials:

A) Captures attention, interests and motivates students (includes original F),
B) Builds on prior knowledge and/or experience of students (includes the original E),
C) Promotes interaction (includes the original D),
D) Other (includes the original A, B, C, G)

In conclusion, instructional design is concerned with the methods of instruction and is closely connected to the use of media in teaching. The literature shows that various types of media have been used in teaching for more than a century and its selection should not

be random but be made in relation to the type of activity and teaching method of the instructional event. Instructional design's theoretical foundations and various theories and models were described in this chapter. They provide guidance for instructors when designing a course, including guidance for the media selection phase.

Some theories from the cognitive psychology domain consider that the human brain creates separate representations of information received visually and aurally. As a result one theory states that "people learn better from words and pictures than from words alone" (Mayer, 2001) and suggest that various types of media should be used in teaching in order to enable the brain to create multiple mental representations. Because there are learners with mental and physical disabilities, these theoretical foundations are helpful in explaining the importance of media accessibility and thinking about it when designing a course. The review of the literature indicated the need to create a list of disability categories and reported the disability incidence in Canada and in some universities. This shows the importance of thinking about selecting media which are accessible to people with disabilities when planning a course. Thus, the selection of media should be influenced by many factors as Gagné (Gagné et al., 2005, p. 230) has noted including sociological, psychological and economic.

Finally, the literature review shows the close connection between instructional design, the theories and models behind it and the selection of media. One of the issues we discovered in the literature review was the lack of instructional design guidelines which prompted us to create a list of rules to allow the assessment of instructors' coverage of IDG of the course materials.

Another gap that we identified in the literature was the lack of unified definitions and categorization criteria of media types and teaching methods which prompted us to develop an ontology that will be discussed in the next chapter.

2. Ontology development

The multitude of definitions of teaching methods and types of media make it necessary to organize them conceptually in a reusable ontology. Ontologies are “explicit formal specifications of the terms in the domain and relations among them” (Gruber, 1993). The development of reusable domain-specific ontologies is considered an important task in informatics in general and medical informatics in particular (Musen, 2002). Developing an ontology of teaching methods and media types was therefore important to this thesis because of its role in building a shared understanding of the various teaching methods and their connection to types of media.

In a previous chapter media was defined as “[…] the physical means of communication” and the sensory channel was “the sensory mode used in a communication (visual, auditory, tactile, kinaesthetic, olfactory, and so on)” (Gagné & Briggs, 1979, p. 175). These two notions (*sensory channel* and *physical medium*) and their definitions are central to this conceptual exploration.

2.1. Sensory receptors, the brain and information processing

An important argument for the need to recognize sensory channels as a distinct notion is based on an important body of evidence coming from brain sciences and that supports the idea that information is processed differently depending on the type of stimuli (e.g. spoken word versus written word). Therefore, this section will review how humans receive and process information in their brains.

Human beings use their sensory system to collect information about the environment. The information is then processed and a response to it is formed. The sensory system is part of the nervous system and consists of sensory receptors, neural pathways and parts of the brain that process the sensory information and responses.

Sensory receptors are specialized cells that respond to internal or external stimuli. According to the type of stimulus that excites them, sensory receptors are categorized as *general* and *special* sensory receptors.

General sensory receptors are receptors sensitive to:

- pain (nociceptors),
- temperature (thermoreceptors),
- physical distortion resulting from touch, pressure and body position (mechanoceptors), and
- chemical molecules (chemoreceptors).

Mechanoreceptors are divided in three classes as follows:

- tactile receptors which are sensitive to touch, pressure and vibration,
- baroreceptors which capture information about changes in pressure in various organs (e.g. blood vessels, digestive tract), and
- proprioceptors which acquire information about joints position, tension in tendons and ligaments, status of muscular contraction.

Special sensory receptors are part of specialized areas or sensory organs (e.g. eye, ear, taste buds) and comprise:

- olfactory receptors,
- gustatory receptors,
- photoreceptors, and
- hair cells (mechanoreceptors in the inner ear).

Table 7 shows the sensory receptors, the type of stimuli that excites them and the human senses they enable. For example, one of the special sensory receptors is represented by photoreceptors. They are located in the eye (a sensory organ), are sensitive to light and enable the sense of vision.

Natural sciences (e.g. physiology, physics) define the notion of stimulus as a change in the environment (internal or external) that corresponds to a certain energy form (e.g. electromagnetic radiation, mechanical force). Sensory receptors detect the energy and make use of it "[…] to trigger electrochemical signals that can be transmitted to the brain - a process called sensory transduction" (Boron, 2002, p. 325).

In education, the term ‘stimulus’ (plural ‘stimuli’) is used with a more general meaning without making clear distinction between the energy forms (e.g. spoken words, still pictures, objects, motion pictures) (Briggs, 1970, 1977, 1979, Rowntree, 1990).

Category	Sensory receptors	Type of stimuli	Sense	Sensory organ / specialized areas
General sensory receptors	Nociceptors	Pain	Pain	
	Thermoreceptors	Temperature	Temperature	
	Tactile receptors	Physical distortion resulting from touch	Touch	
	Baroreceptors	Physical distortion resulting from pressure	Autonomic control of pressure	
	Proprioceptors	Physical distortion resulting from body position	Proprioception (body position)	
	Chemoreceptors	Chemical stimuli	Autonomic control of respiratory and cardiovascular functions	
Special sensory receptors	Olfactory receptors	Chemical stimuli	Olfaction (smell)	Olfactory organs
	Gustatory receptors	Chemical stimuli	Gustation (taste)	Taste buds
	Photoreceptors	Light	Vision	Eye
	Hair cells	Sound	Hearing	Inner ear
	Hair cells	Acceleration, gravitation	Equilibrium (balance)	Inner ear

Table 7. Human senses, sensory receptors and organs

On the other hand, proprioceptors are general sensory receptors located throughout the body and sensitive to physical distortion resulting from changing one’s body position. Sometimes the terms *proprioception* and *kinaesthesia* are used interchangeably. However kinaesthesia appears to be a concept that is more concerned with sensing body movement

and could be considered just the combination of two distinct senses: proprioception and equilibrium. Creating a distinct category for it was therefore unwarranted.

The information received through sensory receptors is sent to various areas of the brain via neural pathways. Each cerebral hemisphere is divided into four regions named lobes: frontal, parietal, temporal, and occipital. The thick layer that covers the surface of the brain, i.e., the cortex, has a key role in memory, perception, language, and other functions that play important parts in learning and teaching. The cortex is formed of neurons and unmyelinated fibers and because of its gray colour is also referred to as the "gray matter". Underneath the cortex there is the white matter of the brain which is formed of the myelinated neurons. The surface of the cortex has multiple elevated ridges called gyri that are separated by depressions called sulci or by deep grooves called fissures (Martini & Bartholomew, 2010).

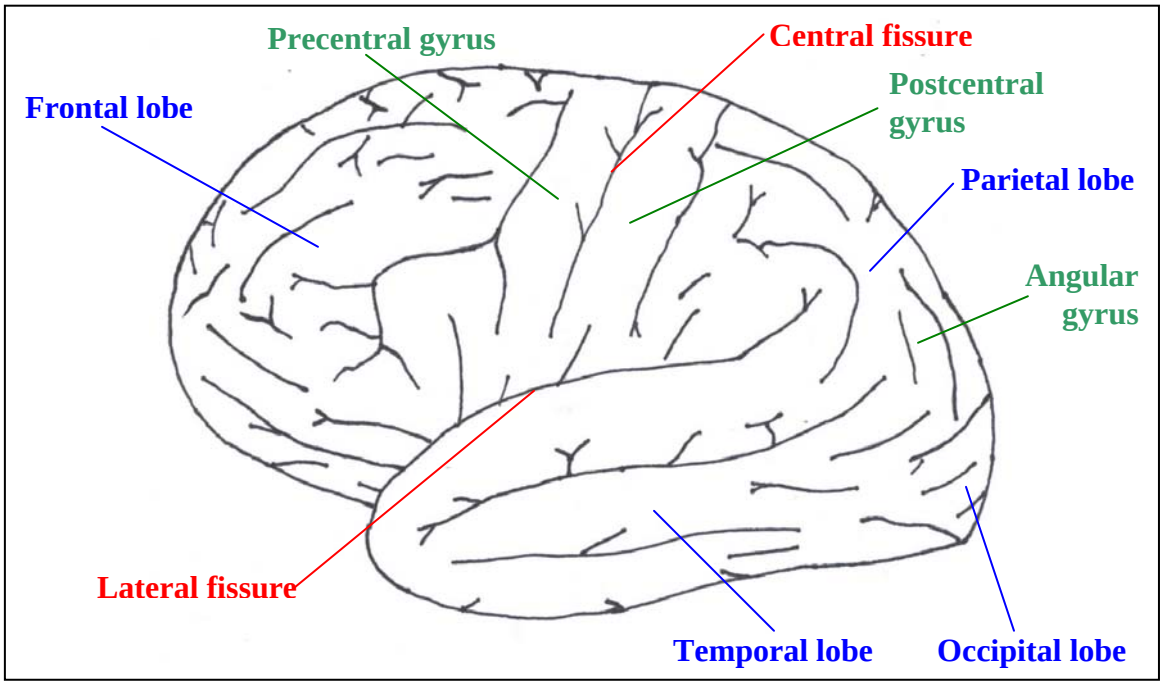

Figure 7. Lateral view of left hemisphere of the brain (lobes in blue colour, gyri in green colour and fissures in red colour)

The areas of the cortex are sensory areas (receive sensory information from sensory receptors), motor areas (neurons in these areas direct voluntary movements) or

association areas (interpret incoming data or coordinate a motor response). Various regions of the cortex are interconnected by the white matter underneath the cortex. Table 8 shows the location and function of some of the cortex areas. For example, the visual cortex is located in the occipital lobe and receives information from the photoreceptors located in the eye.

Area	**Location**	**Function**
Visual cortex	occipital lobe	receive information from photoreceptors
Gustatory cortex	frontal lobe	receive information from gustatory receptors
Auditory cortex	temporal lobe	receive information from hair cells in the inner ear
Olfactory cortex	temporal lobe	receive information from olfactory receptors
Primary sensory cortex	postcentral gyrus of the parietal lobe	receive somatic sensory information from tactile receptors, baroreceptors, nociceptors and thermoreceptors
Primary motor cortex	precentral gyrus of the frontal lobe	direct voluntary movements by controlling somatic motor neurons in the brain stem and spinal cord
Somatic sensory association area	pariental lobe	monitors activity in the primary sensory cortex
Somatic motor association area (premotor cortex)	frontal lobe	coordinating learned movements
Wernicke area (general interpretative area)	posterior section of the superior temporal gyrus of the left (or dominant) hemisphere	receives information from all the sensory association areas. Integrates sensory information with access to visual and auditory memory
Broca area (speech center)	edge of premotor cortex of left hemisphere of the left (or dominant) hemisphere	regulates the patterns of breathing and vocalization required for normal speech

Table 8. Some cortex areas, their location and function

This very brief review of brain structure has clear implications into how brain functions are carried out and is meant to illustrate more clearly the need to distinguish between types of stimuli which are processed in the brain in different areas such as for example, spoken and written language.

The Wernicke-Geschwind model of language shows how the brain processes language based on the type of stimuli. This model is shown in Figure 8 and is also described in a video clip at http://web.his.uvic.ca/hinf591/wernicke/wernicke.html. A verbal input (spoken words) is received in the primary auditory cortex after which it is sent to Wernicke's area where it is interpreted and an answer is formulated. Then information is passed to Broca's area which adds a syntactic structure and a motor response plan. Further information is passed to the motor area that sends signals to the mouth and larynx muscles to produce a spoken word response, if necessary.

If the text is read (written language), the information is received in the visual cortex and then sent to the angular gyrus where the spelling of the word is interpreted. The neurons in the angular gyrus are able to draw connections between an object and its characteristics. They are also responsible with the retrieval of word meaning from short-term memory. From the angular gyrus the information is sent to Wernicke's area where it is recognized as a word associated with an auditory form. From here the message is taking the same route as the spoken word to Broca's area and to the motor areas. Not surprisingly, recent studies (Koelsch, 2006, Maess, 2001) show that Broca's area is also responsible for interpreting music syntax.

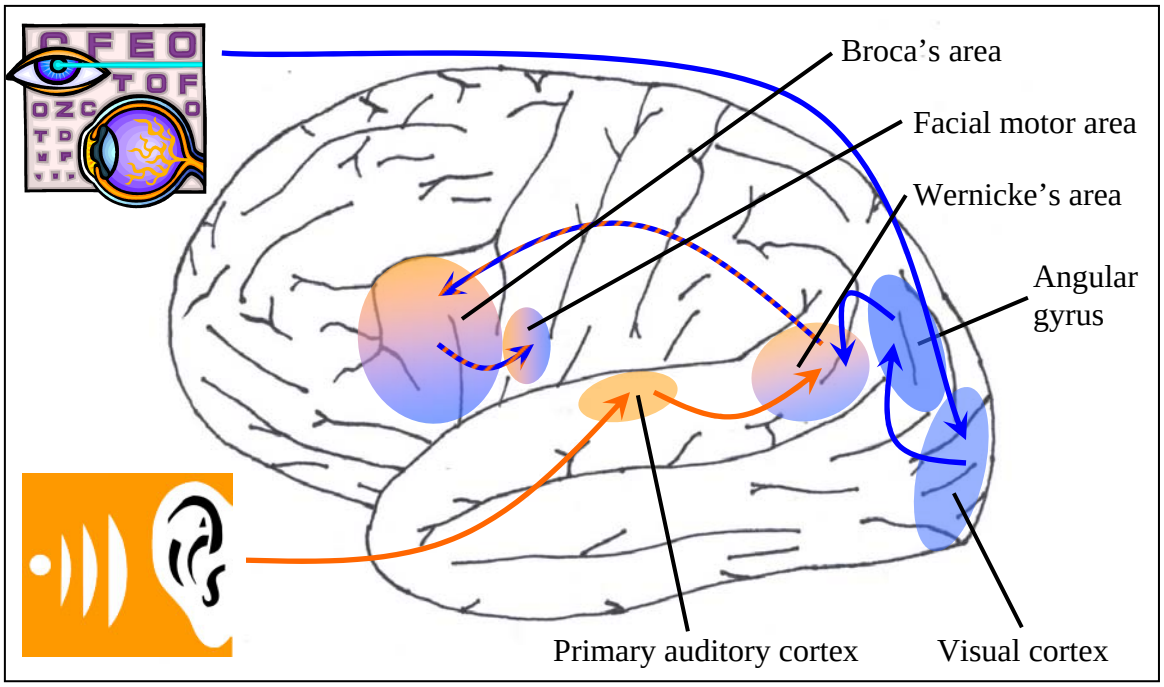

Figure 8. Wernicke-Geschwind model of language

Although the Wernicke-Geschwind Model of Language is a simpler model from the 1960's, newer models (e.g., Mesulam's model) consider that language processing is more complex and varies depending on the task performed. However, the idea that the primary language functions are localized is generally accepted.

The strong connection between structure and function in the brain and the localized way that the information is processed in the cortex can be generalized to functions other than language processing and which are likely to be processed in specialized ways.

This prompted the introduction of a new ontological notion, the '*media format*', which refers to how a medium may be formatted in order to hold the information that is being transmitted through a sensory channel (Table 9). For example, the tactile format is using the tactile sensory channel and consists of objects and tactile language systems (e.g. Braille system). As shown earlier, tactile information is processed in the primary sensory cortex and that distinguishes it from spoken text and written text which are processed in the temporal lobe (i.e. auditory area of cortex) and occipital lobe (i.e. visual area of cortex) respectively. As a result, the ontology defines the common media formats as visual, tactile and auditive. The other media formats (e.g., nociceptive, thermoceptive,

proprioceptive, equilibrium, olfactive and gustative) are considered more uncommon and have all been grouped under the category of *rare formats*.

Media Format	**Sensory Channel**
Visual formats: 1. Symbols 2. Written words 3. Graphics: • Picture • Diagram • Chart • Drawing/Painting 4. Objects/people/living things	Visual
Tactile formats: 5. Objects/people/living things 6. Tactile Language Systems • Braille	Tactile (touch)
Auditory formats: 7. Spoken words 8. Music 9. Sounds (e.g. bird chirping, car, heartbeat)	Auditory
10. Rare formats: • Pain • Temperature • Body position • Balance • Smell • Taste	 Nociceptive Thermoceptive Proprioceptive Equilibrium Olfactive Gustative

Table 9. Type of format categorized by sensory channel

The relationship between media formats and media is many-to-many. A medium can encompass one or more formats and one format can be found in many media. On the other hand, a medium will always require a physical support such as paper, plastic, computer memory, etc. For example, media formats such as written text and graphics (e.g., pictures) can often be found in a medium we commonly refer to as a "book". The physical support for the book medium could be paper or some electronic device. If the latter is the case then the electronic version may be referred to as an e-book whose physical support may be an eBook reader, tablet PC, etc.

During this ontological exercise it has become clear that not all teaching methods and the media involved in them can be differentiated based on the media formats alone. Characterizing the extent in space and time of a teaching method may be needed in order to better define and distinguish between various teaching methods and approaches. For example, the media format of a lecture in a classroom appears to be identical to that of a recording of that lecture. However, from the point of view of time, the first method is synchronous while the latter (i.e., recording of the lecture) is asynchronous. Also, from the point of view of space, the first method is face-to-face while for the latter method the space is irrelevant because the method is asynchronous (learners can play back the recording at any location and time they prefer).

Time and space could be regarded as attributes of a teaching method that, for the purpose of the ontology, could be considered independent of in the media formats employed.

As a result, this ontological work has also evolved towards a matrix representation (Table 10) whose organizational principle is the time-space dimension. This allows the organization of types of media and their physical supports across the space dimension. It also allows the characterization of teaching methods across both time and space dimensions. The extension to time is necessary because teaching methods (e.g., lecture, lab) always represent complex spatio-temporal events that unfold in both space (e.g., a classroom, a laboratory) and in time (e.g., 2 hours long).

Based on Heinich (Heinich et al., 1993), there are nine teaching methods categories as listed in Table 10. Each teaching method can be defined by its time-space characteristics:

- synchronous face-to-face (same time, same space),
- synchronous at distance (same time, different space), and
- asynchronous (different time).

Further, each teaching method can be associated with multiple types of media (book, article, CD, slides, etc.), which could be a combination of up to ten distinct media formats.

Dimension	**Categories**
Teaching method (time-space)	Presentation, Demonstration, Discussion, Drill-and-practice, Tutorial, Cooperative learning, Gaming, simulation, Discovery, Problem solving (Heinich et al., 1993)
Time	Synchronous, Asynchronous
Space	Face-to-face, At distance
Media (information-space)	Book, Digital audio file (e.g., MP3), Instructor, Slides, Motion pictures, etc.
Media Format (information)	Symbols, Written words, Graphics, Objects/people/living things (visual and tactile), Tactile Language Systems, Spoken words, Music, Sounds, Rare (pain, temperature, body position, balance, smell, and taste)
Physical Support (space)	Paper, Computer / electronic device, Plastic (e.g., transparencies), CD-ROM, DVD, etc.

Table 10. The time-space organizational matrix of media and teaching methods

For example, a teaching method has the characteristic of time (synchronous or asynchronous) and space (taking place at distance or face-to-face), it contains media that is characterized by the media format and has a physical support. Figure 9 depicts the ontology and shows that a teaching method is connected with the concepts of time and space as well as physical support and media format.

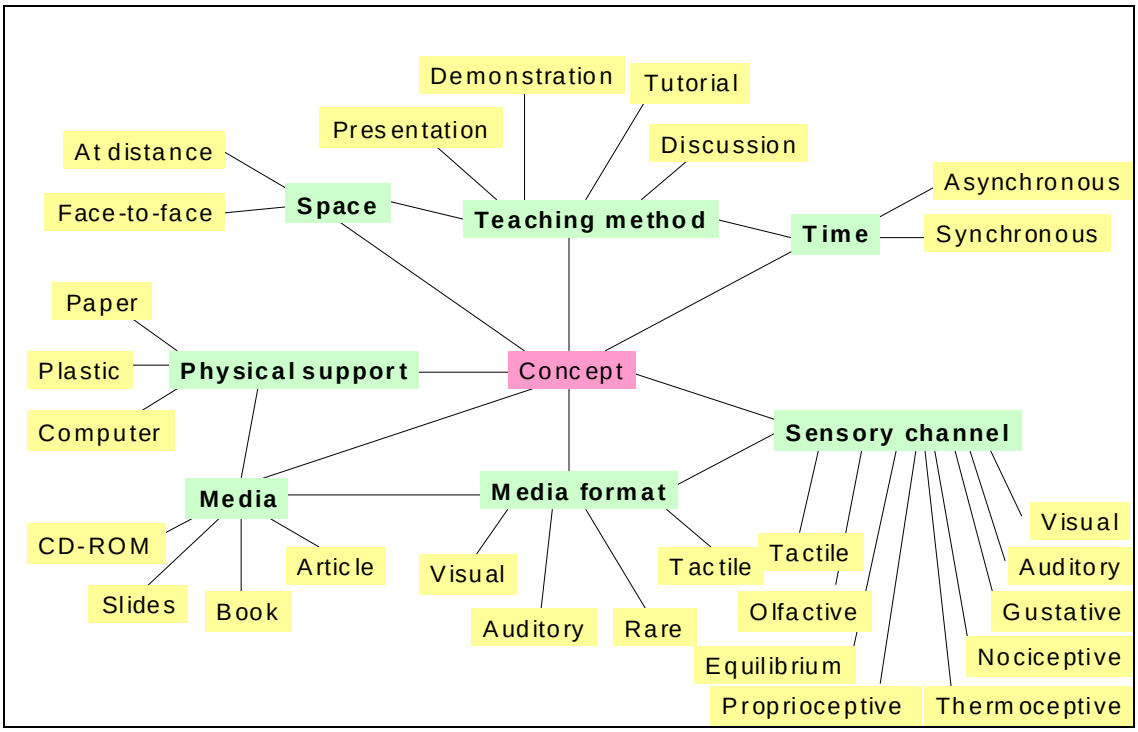

Figure 9. Ontology diagram

In the usual case of a 2-hour long lecture, an instructor may be speaking in front of students in a classroom and may use a set of Power Point slides that are projected on a screen (Figure 10). This teaching method can be defined more precisely in space and time by characterizing it as a synchronous face-to-face presentation by an instructor (the medium). In this specific case, there are at least two media used: the instructor himself and the Power Point slides. Each medium may involve multiple media formats. Commonly, these are:

1. Instructor
    a. auditory format: spoken words
    b. visual format: objects/people/living things
2. PowerPoint slides
    a. visual format: written words
    b. visual format: graphics

In other cases, the instructor may be doing lab demonstrations involving real objects, devices and materials (e.g., a Van de Graaff machine demonstration when teaching the concept of voltage or the difference of electric potential or about static electricity). In

such cases other media and media types may be added to the list in addition to visual format (i.e., object/people/living things) and could consist of the tactile media format (i.e., objects/people/living things) that enables learners to use their sense of touch during learning.

While the category of *rare media formats* may work as such, one could always refine it into individual categories if required by the subjects that are being taught. For example, in a culinary school, smell and taste media formats are very important so they should likely be considered independent categories. More relevant to healthcare, and informatics, the senses of smell, temperature and body position may also need to be distinguished more clearly in the context of medical training given their importance in clinical medicine and surgery.

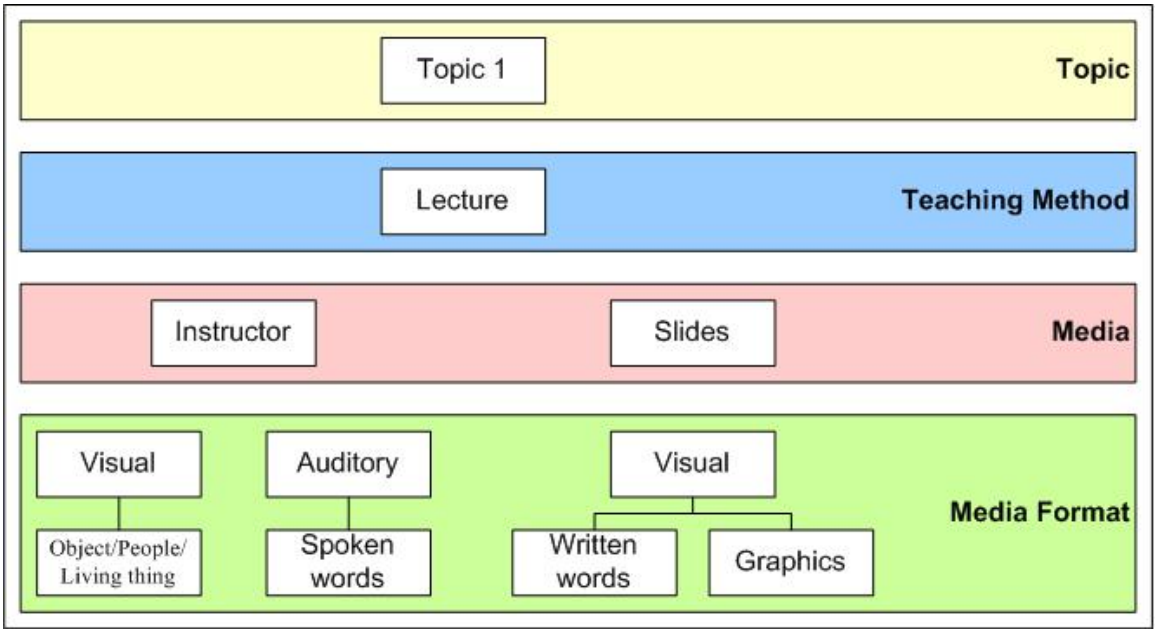

Figure 10. The instruction components

It is important to mention that the term ‘media format’ has been found in the literature but having a different meaning. For example, films, filmstrips, overhead transparencies, cassettes, texts, CDs, DVDs, videogames, etc. are considered media formats (Shea, 1974, Donohue, 2008). A formal definition of this term could not be found in the literature and it is unclear what differentiate the term ‘media format’ from the ‘medium’. Sometimes media format was used to characterize the media: “talking head, voice-under-text, voice-

under-video, multiformat (combination of talking head, voice-under-video, and text)" (Ottaviani, 1994).

Although the sensory channel was a term found in the literature in relation with the term media, it was not completely defined and explored. Most of the time, the only sensory channels or senses mentioned were hearing, sight, smell, touch and body movement (Ely, 1980). The ontology described in this chapter sets clear definitions, describes all the human senses and categorize them.

An additional dimension of the ontology is represented by the level of interactivity that a teaching method may contain. Interaction is extremely important in teaching: an instructor is continuously gathering information in order to understand students' views of the concepts being taught (Laurillard, 2005). "Communication is an interpretative transaction between or among individuals" (Heinich et al., 1993). Schramm's transaction model of communication (Schramm, 1954, p. 119) sees the instructor and the learner having changing roles of sender and receiver. The encoding and decoding is based on instructor's and learner's skill and knowledge. The learner encodes his own interpretation of the signal in order to transmit it back to the instructor. The diagram of the instructional process in Figure 11 is based on Heinich (Heinich et al., 1993) and Schramm (Schramm, 1954) and depicts the relationships between teaching method, medium and media format. It also shows the teaching method as an interactive process between the instructor and the learner where media is a completely integrated component. Each teaching method contains various media (two media in Figure 11), and each medium contains various media formats transmitted between the instructor and learner through specific sensory channels.

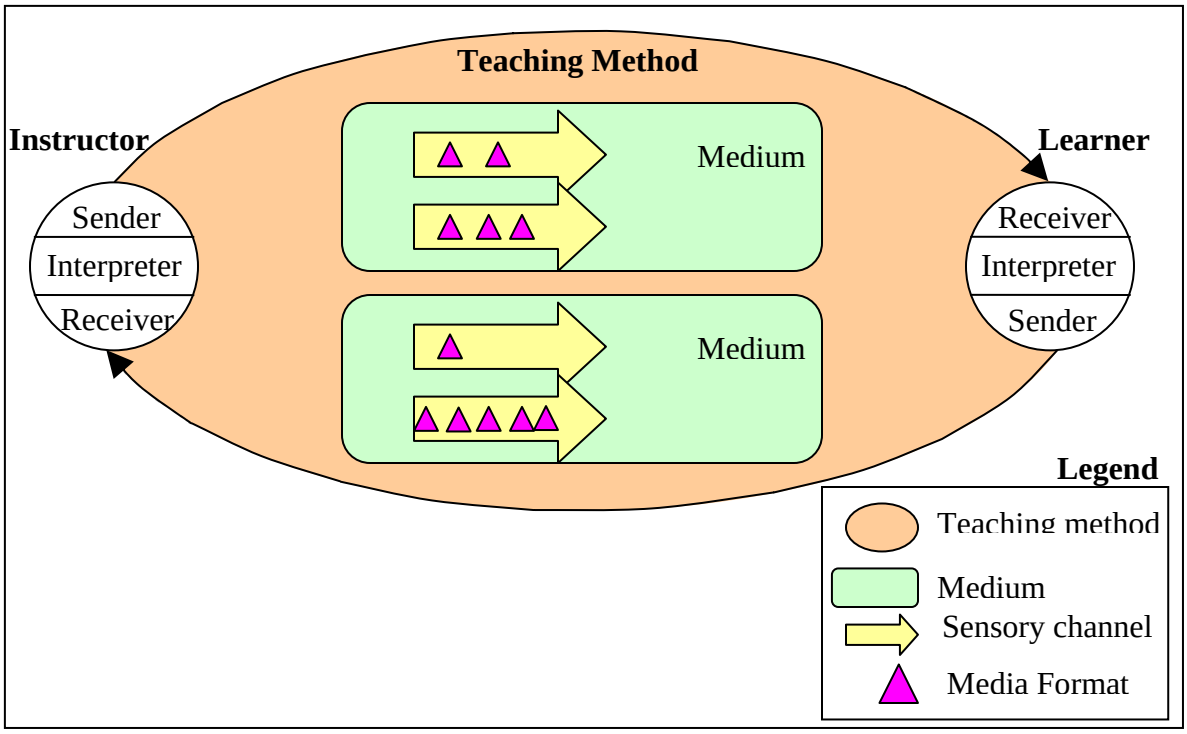

Figure 11. The instruction process showing an example of a teaching method using two media (adapted from Heinich et al., 1993 and Schramm, 1954)

This model shows the relationship between important elements of the instructional process: teaching method, media, media format, sensory channel and student-instructor interaction.

In summary, the ontological exercise has attempted to organize media and teaching methods. The purpose of the ontology was to clarify the concepts of media, media format, and teaching method to build a share understanding of them and to form a more solid basis for the proposal of a more theoretical concept of Media Amplitude (MA) that is introduced in the following section.

2.2. The Media Amplitude (MA) concept

MA is an objective measure of the course content that aims at graphically representing the media richness of course materials. As an objective approach, an attempt was made to provide, as part of this research, a formal algorithmic approach to the calculation of MA. While defining MA formally was possible, the realities of the research methodology (data collection and analysis) which was subject to time constraints (e.g., limited time interview and interaction with participants in this study) have limited the role of MA

calculations to conceptual purposes. The ideal scenario, envisioned at the beginning of this research, would have allowed data collection that could enable calculation of robust measures of MA for several different courses and the provision of feedback to study participants in the form of MA charts. This will allow them to visually analyze the media content of the course materials. However, collecting the data for MA calculations would have been a very laborious process, beyond the capacity of this research project (given the participants' time and involvement). This called for a modification of the data collection approaches and of the analysis methodologies. While the mixed methods approach that was adopted does not allow a direct calculation of MA the concept of media amplitude remains of high relevance and interest for this work at both its current stage as well as for its future developments.

The description of the MA concept is based on the MA calculation and on the MA chart which provides the visual feedback of the results. The MA calculation is described in detail in Appendix A - Media Amplitude (MA) calculation.

In sum, the MA concept remains a proposal for objectively measuring the richness of media/format of course materials. The calculation of MA has the potential to be semi-automated (i.e., calculated semi-automatically through a custom software application). If MA was to be correlated with IDG then instructors could be able to estimate more effectively their compliance with the IDG through an automated MA analysis of their course materials. The feedback provided by a MA analysis would, in principle, inform instructors about their IDG coverage and potentially help them improve it.

3. Methods and approaches

The need to use a mixture of quantitative and qualitative research methods is a well recognized and accepted reality (McDowell & MacLean, 1998). Blending research methodologies is a rapidly evolving approach, with multiple dimensions of complexity that allow for a better research design with fewer biases and limitations. For this study, this combined methods approach was adopted.

The quantitative research methodology adopted falls under the positivist paradigm and aims at quantifying certain aspects of human behaviour that are relevant to teaching. This approach comprises limited but more precise measurements of sample observations followed by a statistical analysis of the collected data. The aim of the analysis is to describe mathematically existing relationships and patterns that can be generalized. In this study, the quantitative methods were developed as a pilot study for a potential future study or evaluation tool. Despite the small sample of 20 subjects, it was anticipated that the discipline of a formal quantitative analysis would reveal areas for improvement, such as subject selection, defining hypotheses or the measurement of variables.

The qualitative research was based on the study of recorded verbal descriptions and observations of human behaviour. Though the qualitative research approach is less generalizable, it has, as expected, provided more comprehensive, detailed and precise information about the human behaviours and practices studied and, most importantly, the rationale behind the behaviours and practices. The qualitative data analysis approaches used were content analysis, quotes from interviews, and in-depth examinations. Data was coded using either a priori codes (set of existing codes developed before examining the data) or inductive codes (codes developed while examining the data). The findings consist of themes that emerged from the data, frequencies and percentages of codes belonging to specific themes, as well as important quotes from the interviews. The goal of the qualitative research was not to generalize but to focus on the personal, on the subjective experiences and on special cases and exceptions.

The advantage of using a mixed methods approach is represented by the breadth of information that is gathered through both methods.

3.1. Subjects

The study involved 20 instructors from 13 schools, departments or programs at the University of Victoria, British Columbia and at Conestoga College, Ontario. The aim of the study was to recruit participants from as many departments as possible in order to enable the generation of hypotheses about the modifiers of the relationship of interest. Prior to beginning the study, it was also decided that a sample size of 15-20 participants would allow for conducting a pilot quantitative and qualitative analysis.

The following is a hierarchical description of all the organizational entities involved in the study:

University of Victoria

- Faculty of Human and Social Development
    1) School of Health Information Science
    2) School of Social Work
- Faculty of Social Sciences
    3) Department of Geography
    4) Department of Political Science
    5) Department of Psychology
- Faculty of Science
    6) Department of Biochemistry and Microbiology
    7) Department of Biology
- Faculty of Engineering
    8) Department of Computer Science
    9) Department of Electrical and Computer Engineering

Conestoga College

- School of Health & Life Sciences and Community Services
    10) Program of Health Informatics Management
    11) Program of Human Services Foundation
- Conestoga Language Institute
- School of Liberal Studies & Communications

3.2. Materials

A laptop computer was used to collect data for the study. Depending on the way the interviews were conducted (online or face-to-face), a variety of computer software and hardware was employed. The materials needed for conducting the interviews are listed in Table 11.

Interviews	Software	Hardware
Online	i. Elluminate Live – web conference tool that allows transmission of voice, text, display of slides, etc. (http://www.elluminate.com/) ii. Skype – audio conference software that allows transmission of voice, video and text. (http://www.skype.com/) iii. MP3 Skype recorder – software that allows audio recording of a Skype call. (http://voipcallrecording.com/)	i. Computer ii. Headset (microphone and headphones) iii. Phone (used only when computer microphone/speakers were not working)
Face-to-face	i. Audacity – software for audio recording and editing. It was used to record the audio of the face to face interviews (http://audacity.sourceforge.net/)	i. Laptop computer ii. Wireless microphone

Table 11. Materials needed for conducting the interviews

A set of PowerPoint slides (Appendix B – Interview slides) were used to provide the participants with a quick overview of the study and to clarify the terminology used in the interview (e.g., types of media, teaching methods, IDG). Initially the terminology was not in its final form and the term ‘media’ was replaced later in the study with the term ‘media format’.

A screenshot of an Elluminate session is shown in Figure 12. The slides can be visualized on the 'whiteboard' which is located on the right side of the screen.

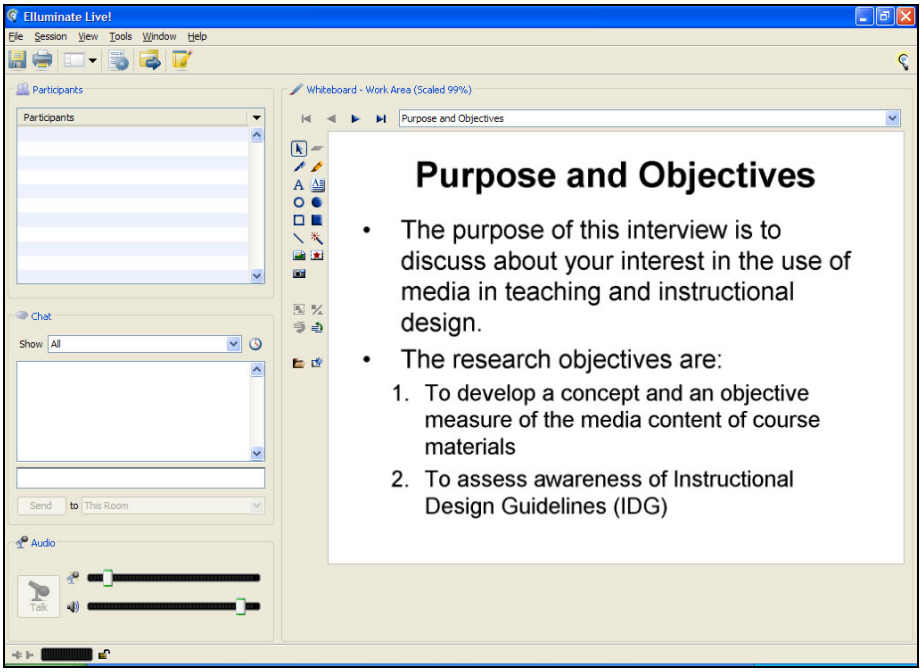

Figure 12. Elluminate screenshot

3.3. Procedures

The participants were recruited via an invitation for participation email sent through each department's secretary, graduate secretary or the instructors. The consent form for participation was attached to the invitation email and potential participants were asked to reply to the investigator (i.e. Felicia Pantazi) if they were interested in participating. The invitation for participation and the consent form are included in Appendix C – Invitation for participation and Appendix D – Consent form.

The interviews were scheduled to take place as either online or face-to-face meetings. They began with a short overview of the study, definitions and clarification of terminology used throughout the interview. The interviews were conducted as follows:

- 13 online interviews:
    - 10 interviews via Elluminate. Voice and slides were used. Nine interviews were recorded; one participant did not agree to be recorded.

  - 2 interviews via Elluminate and phone. Slides were delivered via Elluminate live but, due to technical difficulties, the voice/audio component of the interview was done via phone. One interview was recorded.
  - 1 interview via Skype. Slides could not be displayed, only the voice/audio component of the interview was completed. The interview was recorded.
- 7 face-to-face interviews. Slides were shown on a laptop. All face-to-face interviews were recorded.

The recordings of the interviews were analyzed and used occasionally to validate and complement the investigator's written notes taken during each interview. Each interview was semi-structured and had three main focus areas:

- media usage in teaching,
- the IDG usage in planning a course, and
- the exploration of the relationship between the use of media in a course and instructional design.

Additional questions were asked as they arose from the discussion, such as whether the interviewee had any difficulties in finding appropriate media, what were the types of courses they were teaching (e.g., online, face-to-face, undergraduate, graduate) and the number of years of teaching experience.

3.4. Data Analysis

The interviews were coded and the data was introduced into a Microsoft Excel spreadsheet for analysis.

3.4.1. Qualitative Analysis

The following inductive codes were identified as part of the qualitative analysis:

1. **Time (values: yes/no)**. The participant mentioned that selecting or developing media resources was time consuming.

2. **Technical (values: yes/no)**. The participant mentioned that technology support was needed in order to deliver some types of media or that issues of a technological nature were encountered.
3. **Feedback (values: yes/no)**. The participant mentioned that student feedback was important and changing the course content or delivery approach was based on the feedback received.
4. **Instructional design (values: known/unknown).** The participant knew or did not know about instructional design before the interview.

The following a priori code was used as part of the qualitative analysis:

5. **Potential relationship between use of media and thinking of IDG while preparing a course (values: yes/no/unknown).** The participant's answer to question 3 of the interview.

Using the a priori code, the positive (answer 'yes), negative (answer 'no') and unknown (answer 'don't know' or 'can't tell') answers to question 3 were counted.

The inductive codes allowed counting of the reported time and technical issues. The number of instructors that considered student feedback an important part of the course development was also counted.

Further analysis allowed counting the number of instructors that were not aware of instructional design principles but who acknowledged the possibility of a relationship between IDG and media when planning a course.

Representative quotes were extracted from the interviews for detailed discussion in the results chapter.

3.4.2. Quantitative Analysis

From an epidemiological point of view, this pilot research has the structure of a retrospective cohort study that aims to determine whether the usage of various types of media in teaching (the cause) results in an increased coverage of IDG (the effect). Assessing participants' IDG and media usage in their teaching was done by using two methods:

- A subjective method, based on subject's self-assessment and
- A more objective method, based on the investigator's analysis of interviews.

For the purposes of data analysis, the following data fields have been defined and have been added to the data columns from the qualitative analysis:

6. **Identification Number**. Unique identification number assigned and used to identify each participant in lieu of their name after the data was introduced into the spreadsheet.
7. **Question 1**. Participant answer to question #1 (i.e., self assessment of their usage of various types of media in teaching) represented as a number between 1 and 5. The answers formed the basis of a coding referred to as "*Media usage Perceived by the Participant*" with two distinct categories:
   - Low Media (M-), when answer values were between 2 and 5 and it defined the instructor's perceived use of media types as low, and
   - High Media (M+) when the answer value was 1 and it defined the instructor's perceived use of media types as high.
8. **Question 2**. Participant answer to question 2 (i.e., self-assessment of their awareness of IDG when developing course content) represented as a number between 1 and 5. The answers formed the basis of a coding referred to as "*IDG usage Perceived by the Participant*" with two distinct categories
   - Low IDG (IDG-) when answer values were between 2 and 5 and it quantified the fact that the instructor's perception of IDG awareness was low, and
   - High IDG (IDG+) when the answer value number was 1 and it quantified the fact that the instructor's perceived awareness of IDG was high.
9. **Field of study**. Participant classification under one of the following two major fields of study:
   - Social Sciences (Faculty of Human and Social Development and Faculty of Social Sciences, School of Health & Life Sciences, Conestoga Language Institute, School of Liberal Studies and Communications) and
   - Natural Sciences (Faculty of Science and Faculty of Engineering).

10. **Online/On campus**. The delivery type of the courses taught by participants (online, on campus or both).
11. **Grad/undergrad**. The level of the courses taught by participants (graduate courses, undergraduate courses or both).
12. **Capture Attention**. A binary field quantifying participant concern with capturing learners' attention and interest and with motivating them, as supported by the interview data.
13. **Building on prior Knowledge**. A binary field quantifying participant concern with building on learners' prior knowledge and/or experience.
14. **Interaction student-instructor**. A binary field quantifying participant concern with promoting student-instructor interaction.
15. **Interaction student-student**. A binary field quantifying participant concern with promoting student-student interaction.
16. **Interaction student-content**. A binary field quantifying participant concern with promoting student-content interaction.
17. **Other**. A binary field quantifying participant concern with other matters when developing course content.
18. **Total IDG usage**. A calculated (sum) numeric field with values between 0 and 6 derived from items 10-13 and which aimed at quantifying more objectively the usage of IDG. Even though the participants self-assessed themselves in terms of their thinking of IDG when developing a course (Question 2), it was necessary to assess IDG based on their other answers to the IDG related questions (e.g., capture learners' attention, build on prior knowledge/experience, promote interaction). This approach, referred to as *IDG usage Based on the Analysis*, consists of defining a threshold between values of 4 and 5 such that:
    a. a value lower than 5 was coded as low IDG exposure (IDG-) and
    b. a value equal or higher than 5 was coded as high IDG exposure (IDG+).
19. **Class size**. An alphanumeric field (L and/or S) which represents whether, in general, the number of students in the classes taught by an instructor was equal to or higher than 25 or not.

20. **Years of teaching**. A binary field representing that the participant's number of years of teaching was equal to or lower than 10 or higher than 10.

The following seven data fields were created to assess objectively whether or not the participants were using various types of media in their courses

21. **Formula**. A binary field quantifying participant usage of mathematical formulae in their courses.
22. **Text**. A binary field quantifying participant usage of text-based materials in their courses.
23. **Graphic**. A binary field quantifying participant usage of graphics (pictures, charts, diagrams, etc.) in their courses.
24. **Visual Live (with Audio)**. A binary field quantifying participant usage of live videos/visual information in their courses. For example, both a live in class lecture or a live TV show would be included in this category
25. **Visual Recorded (with Audio)**. A binary field quantifying participant usage of recorded videos in their courses.
26. **Auditive Information Live.** A binary field quantifying participant usage of live audio in their courses. The audio could be part of a live radio transmission.
27. **Auditive Information Recorded**. A binary field quantifying participant usage of recorded audio in their courses.
28. **Tactile/Gustative/Olfactive Information**. A binary field quantifying participant use of objects that could be seen, touched, smelled or tasted by the audience.
29. **Total media usage**. A calculated (sum) numeric field with values between 0 and 8, derived from items 15-20 and which aimed at quantifying objectively the media usage. Even though the participants self-assessed themselves in terms of their usage of various types of media (Q1), it was necessary to assess media usage based on their other answers to the media related questions. This approach, referred to as *Media usage Based on the Analysis* consisted of defining a threshold between values of 4 and 5 such that:
    a. a value lower than 5 was coded as low media usage (M-) and
    b. a value equal to or higher than 5 was coded as high media usage (M+).

The statistical analysis employed standard epidemiologic methods for discrete data so that the relationship with the hypotheses was clear. The exposure and outcome measures were expressed as binary variables and counts were displayed in 2-by-2 contingency tables. The measures of association were probability differences and ratios (which in epidemiology are called risk differences and relative risks). Two main contingency tables are shown as Table 12, one based on the 'subjective' definitions of Media and IDG as *Perceived by the Participant* and another based on the 'objective' definitions of Media and IDG as perceived by the investigator (derived from calculations based on responses to questions).

	Perceived by the Participant	
	M-	**M+**
IDG+		
IDG-		

	Based on the Analysis	
	M-	**M+**
IDG+		
IDG-		

Table 12. Analysis contingency tables

In addition, stratification analysis of the data (adjusted analysis) was made possible by using the fields of study of the participants:

- Social Science (e.g., geography, psychology, political science, social work, health information science) and
- Natural Science (e.g., biology, microbiology and biochemistry, computer science, electrical engineering).

Further analysis was possible within the Social sciences group where the results were adjusted for years of teaching experience. The adjusted analysis was needed in order to assess the confounding and the effect measure modification of these two variables. The calculation of unadjusted and adjusted risk differences (RD) allowed us to determine whether the effect of Media over IDG is modified by the years of teaching (effect measure modification).

The calculation of RD showed the causal relationship between the variables (i.e. Social science, teaching experience) and IDG. The calculation of the prevalence difference (PD)

of teaching experience between the two media groups (PDt|m) was an indicator of the imbalance. The multiplication of Risk Difference of teaching (RDt) by Prevalence Difference of teaching given media (PDt|m) is called the confounding product (CP) (Maclure & Schneeweiss, 1997) and represents the total amount of confounding by teaching experience in the association between Media and IDG.

The reproducibility of the main measures was assessed using 2-by-2 contingency tables as well. It was assumed that the investigator's classification based on the analysis of responses to questions was the more objective measure, and that the accuracy of the subjective measure (the participant's self-assessment) was expressed in terms of its sensitivity and specificity relative to the more objective measure (Table 13).

	Based on the Analysis	
Perceived by the Participant	**M-**	**M+**
M+		
M-		

	Based on the Analysis	
Perceived by the Participant	**IDG-**	**IDG+**
IDG+		
IDG-		

Table 13. Reproducibility contingency tables

The next chapter describes the results of the study and a conclusion underlying the importance of using a mixed methods approach.

4. Results

Results of the quantitative analysis using epidemiological methods for binary variables are presented first because its purpose was to clarify hypotheses. This analysis can also be considered a pilot study that demonstrates a feasible methodology for a future research project with more participants.

The qualitative analysis is presented second to assist with interpreting the quantitative analysis and to enable preliminary conclusions.

4.1. Quantitative Analysis

4.1.1. Reproducibility Analysis of IDG and Media Measurements

During the interviews it was noticed that some instructors who were "considering IDG" when planning a course ended up not "covering IDG" principles in their teaching. It is therefore important to assess the association between 'covering IDG' and 'considering IDG' when planning a course. Assessing this association can be done in several ways using 2-by-2 contingency tables. One way assumes that the investigator's classification based on the analysis of responses to questions is the more objective measure. Therefore, the accuracy of the subjective measure (the participant's self-assessment) is to be expressed in terms of its sensitivity and specificity relative to the more objective measure. Another way is to assume that neither measure is better than the other, and to do a reproducibility analysis of the data.

	Based on the Analysis		
Perceived by the Participant	**M-**	**M+**	
M+	7	4	PPV=0.36
M-	5	4	NPV=0.56

Sensitivity = 0.50
Specificity = 0.42

	Based on the Analysis		
Perceived by the Participant	**IDG-**	**IDG+**	
IDG+	7	6	PPV=0.46
IDG-	3	4	NPV=0.43

Sensitivity = 0.60
Specificity = 0.30

Table 14. Reproducibility analysis

The sensitivity and specificity of the subjective measure, relative to the more objective measure, were found to be low: 50% and 42% respectively for Media and 60% and 30%

respectively for IDG. This indicates that that the participant self-assessments lack accuracy and that a future study should consider assessing the participants using only more objective methods, based on the codes developed here.

In the reproducibility analyses, the proportion of agreement for Media as well as IDG was 45%. The Kappa statistic for agreement can be likened to a percentage of agreement 'adjusted by chance'. The values of the Kappa statistic were 0.08 for Media and -0.10 for IDG. These negative results mean that there is no agreement between the two methods of assessment under discussion.

Another measure of reproducibility, the correlation coefficient (Phi-coefficient), was also calculated. Again the results indicate disagreement (phi-coefficient for Media is -0.082 and for IDG is -0.10) between the two methods of assessment.

In sum, the analysis results indicate that there is no reproducibility between the two methods of assessment (i.e. Media and IDG *Perceived by the Participant* versus *Based on the Analysis*).

4.1.2. Unadjusted (crude) Analysis

One way of choosing among measures is to assess their relationship to other variables. In Table 15, we examine the crude relationship between use of Media and IDG first by using the 'subjective' definitions of Media and IDG as *Perceived by the Participant* and second by using the more 'objective' definitions of Media and IDG derived by the investigator from the analysis of responses to interview questions.

	Perceived by the Participant		
	M-	**M+**	
IDG+	7	6	13
IDG-	2	5	7
	9	11	20
RR = (6/11)/(7/9) = 0.7 RD = (6/11)-(7/9) = -0.23			

	Based on the Analysis		
	M-	**M+**	
IDG+	4	6	10
IDG-	8	2	10
	12	8	20
RR = (6/8)/(4/12) = 2.3 RD = (6/8)-(4/12) = 0.42			

Table 15. Results displayed in 2-by-2 contingency tables

The analysis of the data *Perceived by the Participant* shows that the RR was in the opposite direction from what was expected. The probability of self-reported IDG was lower when more use of Media was self-reported.

The results of the data *Based on the Analysis* made more sense because they were based on a more objective assessment method.

The unadjusted analysis showed a risk ratio (RR) of 2.3 meaning that the conditional probability of IDG+ given M+ is 2.3 times higher than the conditional probability of IDG+ given M-. This is consistent with the hypothesis of an association between IDG+ and M+. In plain language, the meaning of a RR=2.3 is that instructors who use more media (M+) in teaching are 2.3 times more likely to cover IDG principles than instructors who use less media (M-). This consistency with prior expectations suggests the more objective measures *Based on the Analysis* are better measures of the phenomena we wish to study.

4.1.3. Adjusted Analysis

In order to determine whether the association between media use and IDG can be explained by the field of study or by an instructor's years of experience, an adjusted analysis was needed to assess the confounding and the effect measure modification of these variables.

The data were stratified by field of study into two groups: Social Science (e.g., geography, psychology, political science, social work, health information science) and Natural Science (e.g., biology, microbiology and biochemistry, computer science, electrical engineering) (Table 16). The overall Risk Difference (RD) in the M+ group for the Social Science field of study is 0.41 (highlighted in Table 16) and later this RD will be used in the analysis.

	Social Science		**Natural Science**	
	M-	**M+**	**M-**	**M+**
IDG+	4	6	0	0
IDG-	5	1	3	1
	9	7	3	1

RR =	(6/7)/(4/9) = 1.9	not defined
RD =	(6/7)-(4/9) = 0.41	0

Table 16. Stratification for Social Science group

Further analysis within the Social Science group and adjusted for years of teaching experience, showed that the use of media is more strongly associated with IDG in instructors with low teaching experience (Table 17, RR=3 and 1.6). On the other hand, due to the small sample, this stratified analysis hinged on just 2 key people: one Low teaching, M- and IDG+ in Social Science, and one High teaching, M+ and IDG- in Natural Science.

	Social Science				**Natural Science**			
Teaching	**Low**	**Low**	**High**	**High**	**Low**	**High**	**Low**	**High**
	M-	**M+**	**M-**	**M+**	**M-**	**M-**	**M+**	**M+**
IDG+	1	2	3	4	0	0	0	0
IDG-	2	0	3	1	0	3	0	1
Total	3	2	6	5	0	3	0	0
RR =	(2/2)/(1/3) =3		(4/5)/(3/6) = 1.6		not defined		not defined	
RD =	(2/2)-(1/3) =0.67		(4/5)-(3/6) = 0.3		0		not defined	

Table 17. Stratification adjusted for years of experience

Because the overall RD value (0.41) is in-between the stratified RD values of 0.67 and 0.3, then teaching experience is an effect measure modifier which means that the effect of Media over IDG is modified by the years of teaching.

In the Social Science group, there were twice as many M+ instructors with high teaching experience as those with M+ and low teaching experience (less than 10 years). Further calculations of the risk ratio (RR), risk difference (RD), and prevalence difference (PD) allowed us to determine the confounding product. A confounding product equal to zero means that there is no confounding.

Figure 13 depicts the results of the stratified analyses using causal hypothesis diagrams for the teaching and social science fields. The hypothesis is that the use of media (M+) causes coverage of IDG (IDG+). The additional hypothesis is that teaching and social science are potential confounders. A confounder is usually correlated with the agent, in our case M+, but also impacts IDG.

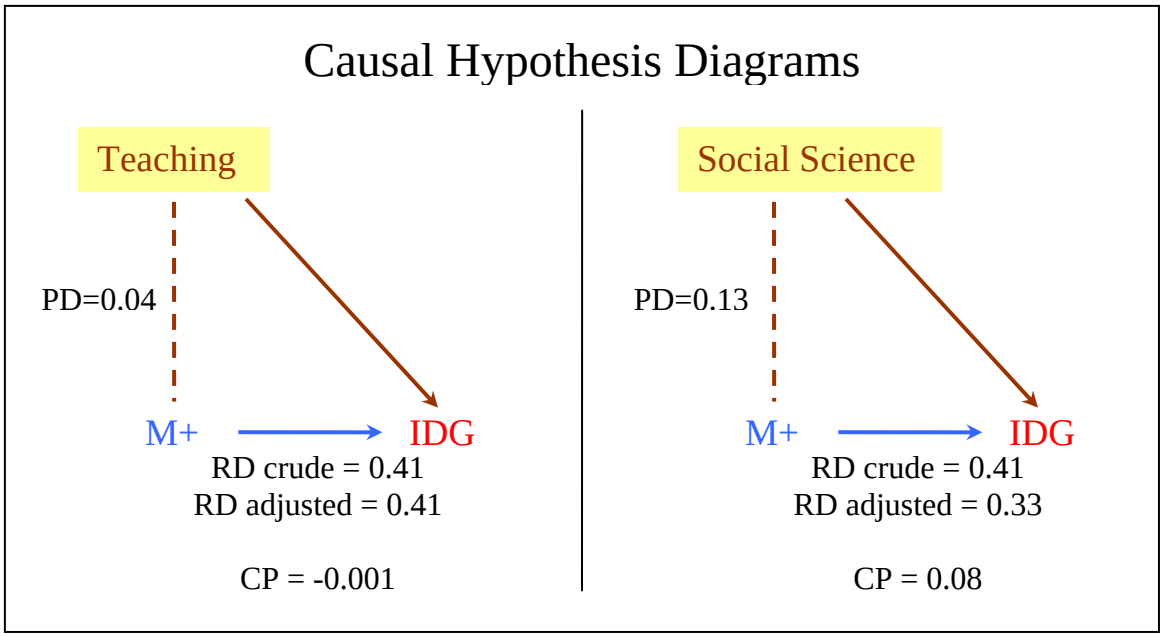

Figure 13. Causal hypothesis diagrams showing the RD, PD and CP

Calculation of prevalence difference of teaching given media (PDt|m) allows further determination of the confounding product (CP) (Table 18). The results indicate that the teaching experience is not a confounder because the Confounding Product is almost zero (only -0.001).

Teaching	**Low**	**High**		**Low**	**High**	
	M-	**M-**		**M+**	**M+**	
IDG+	1	3		2	4	
IDG-	2	3	Total	0	1	Total
	3	6	9	2	5	7
RR =	(3/6)/(1/3) =1.5			(4/5)/(2/2) = 0.8		
RD =	(3/6)-(1/3) =**0.17**			(4/5)-(2/2) = **-0.2**		
Prevalence difference (PD) = = PDt|m = 5/7 – 6/9 = 0.04						
Confounding product (CP) = PD*RD = 0.04*(**0.17-0.2**)/2 = -0.001						
RD adjusted = RD crude – CP = 0.41 – 0.001 = 0.41						

Table 18. Stratification for Social science group adjusted for years of experience given media

The results also support that the Social science field is a confounder (Confounding Product =0.08) (Table 19). Therefore the effect of Media over IDG is confounded by the Social science field.

Social	**Low**	**High**		**Low**	**High**	
	M-	**M-**		**M+**	**M+**	
IDG+	0	4		0	6	
IDG-	3	5	Total	1	1	Total
	3	9	12	1	7	8
RR =	(4/9)/(0/3)			(6/7)/(0/1)		
RD =	(4/9)-(0/3) =**0.44**			(6/7)-(0/1) = **0.85**		
Prevalence difference (PD) =	= PDs|m = 7/8 – 9/12 = 0.13					
Confounding product (CP) = PD*RD = 0.13*(0.44+0.85)/2= 0.08						
RD adjusted = RD crude – CP = 0.41 – 0.08 = 0.33						

Table 19. Stratification adjusted for Social science field given media

4.1.4. Predictive Analysis

Assuming that the association between the media and IDG is real, one possible way of determining, on a continuous basis, the uptake of IDG in teaching would be to monitor the use of media in teaching. This is similar to how, in healthcare and biomedicine, patient conditions are monitored through tests that are easy to administer and interpret and which have certain predictive value for a particular medical condition.

In Table 20 “Media use” represents the test while the “coverage of IDG” is the condition that requires a diagnosis. The true positives (TP=6) are the participants that are using media (+) and that cover IDG (Yes) when planning a course. The true negatives (TN=8) are the ones that are not using media (-) and do not cover IDG (No). The false positives (FP=2) are the participants that are using media (+) but do not cover IDG (No). These are instructors who, even though they were using various types of media, did not cover IDG, not even by coincidence. The false negatives (FN=4) are the participants that did not use media (-) but covered IDG (Yes) in a significant way. Interestingly, two of the false negatives (one of whom had low teaching experience) covered IDG principles without using Media but were determined not to have formally known about instructional design before the interview.

		IDG		
		No	Yes	Total
Media (test)	+	**2**	**6**	8
	-	**8**	**4**	12
		10	10	20

Test Predictivity	
Positive Predictive Value (PPV)	0.75
Negative Predictive Value (NPV)	0.67

Test Accuracy	Sensitivity	0.60
	Specificity	0.80

Table 20. Test predictivity and accuracy using analysis-based data

A test's accuracy is measured by sensitivity and specificity while a test's predictivity is measured by positive predictive value (PPV) and negative predictive value (NPV). The results show that the chance of the test detecting IDG coverage when media is used is 60%. The chance of test not detecting IDG if not using media is 80%. Among Media + instructors the probability of covering IDG is 75% while among Media - instructors the probability of not covering IDG is 67%.

These results support the idea that instructors who use media in their teaching still have a 75% chance of covering IDG principles despite the lack of consideration of IDG principles when planning their courses. This could be useful for course planning, especially by instructors who are not aware of IDG principles: the mere use of media potentially results in the coverage of IDG principles in 75% of the cases. On the other hand, instructors who are neither using media in their courses, nor considering instructional design principles in their planning, have a 67% chance of not covering IDG.

4.2. Qualitative Analysis

Based on the inductive codes developed, 60% of the participants reported time being an issue in selecting and/or using media while 40% of the participants reported technical issues (Figure 14). 75% of the participants mentioned that they change the course content and/or delivery based on feedback received from students.

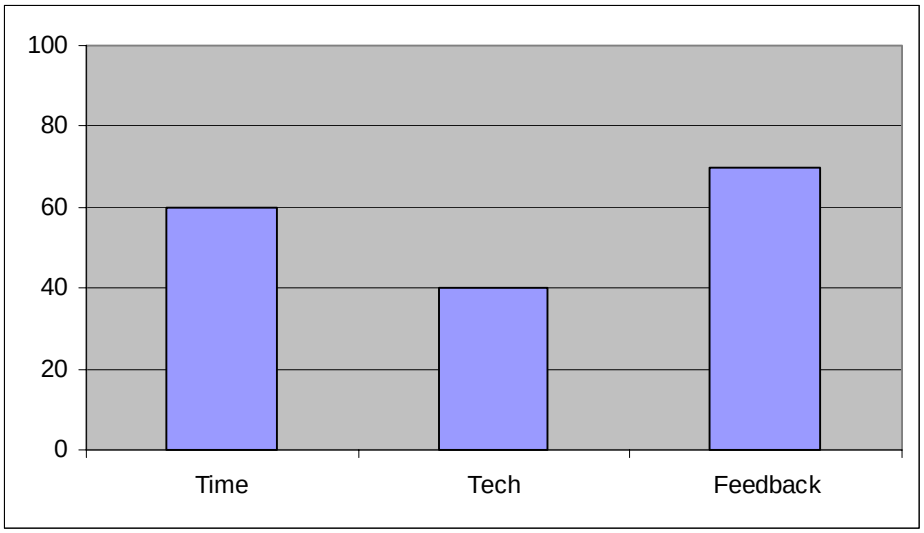

Figure 14. Percentage of participants reporting time and technological issues and feedback

Based on the answers given by the participants to question 3 (whether there is a potential relationship between the use of media and their thinking of IDG when planning a course), 85% of the participants (17) answered 'yes', 5% answered 'no' (1 participant) and 10% (2 participants) answered 'don't know' (Figure 15).

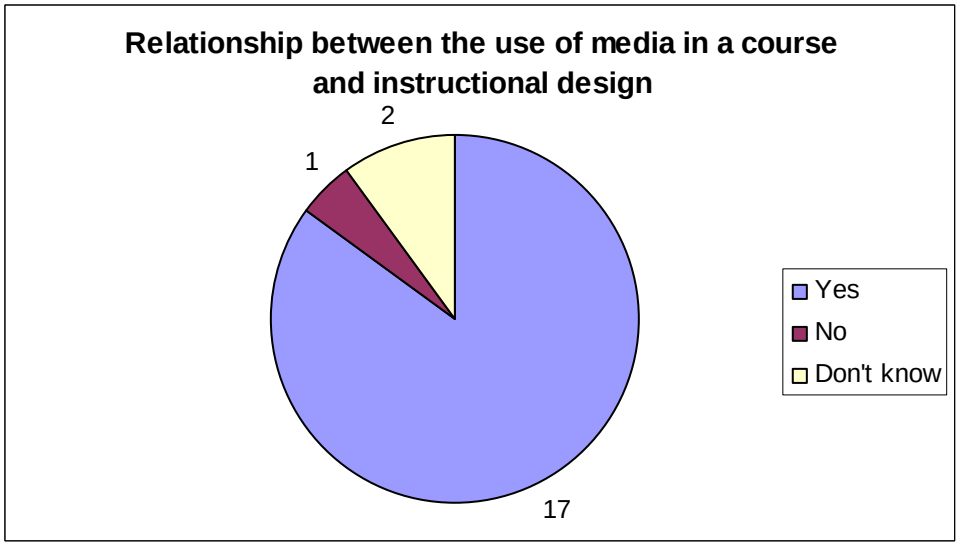

Figure 15. Participants' answers to Question 3

Figure 16 shows the count of answers to Question 3 grouped per knowledge of instructional design (ID). Half of the participants did not know about ID before the interview. After introducing IDG during the interview, 80% of them (8 participants)

considered there to be a relationship between IDG and media when planning a course while 20% (2 participants) did not know whether such a relationship exists.

Out of the 50% of participants that knew about ID before the interview, 90% agreed to the existence of a relationship between IDG and use of media, while 10% (1 participant) disagreed.

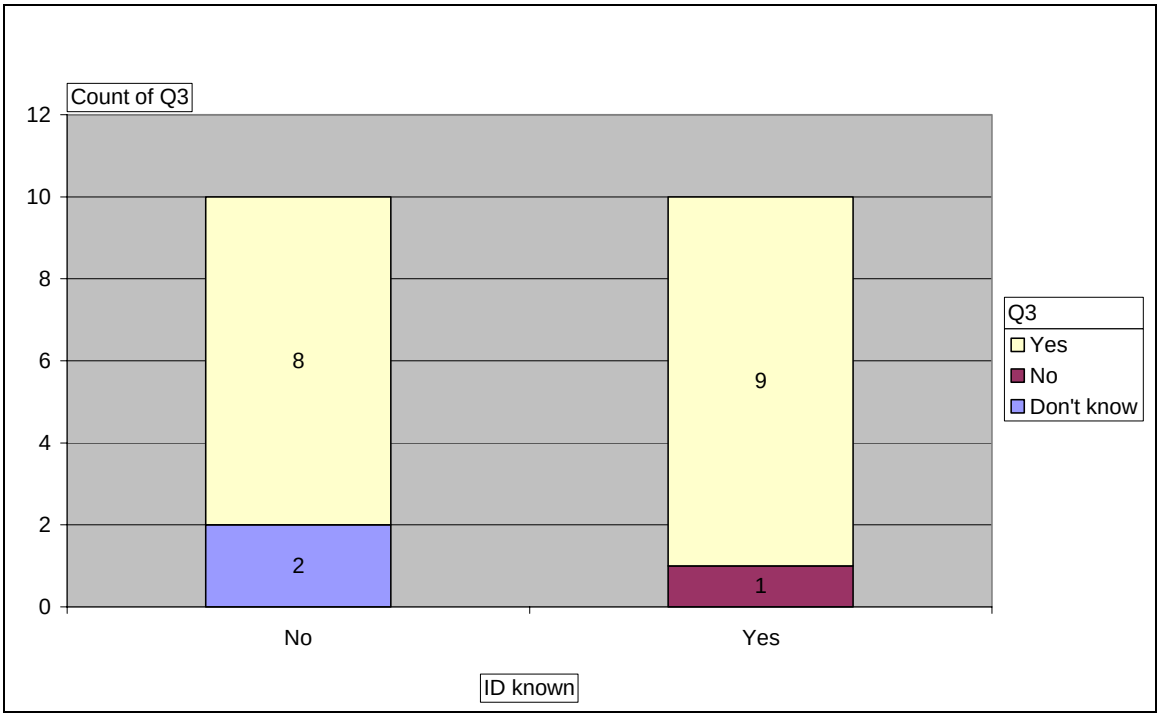

Figure 16. Count of answers to Question 3 identified per knowledge of ID

An interesting aspect revealed by this question is though half of the participants (ten) did not know about instructional design prior to the interview, four of them were covering IDG when planning their courses (Figure 17). Even more interesting is that 2 out of these 4 participants were classified as M- and both of them were teaching Social Science courses, one with low teaching experience (under 10 years) and one with high teaching experience (over 10 years).

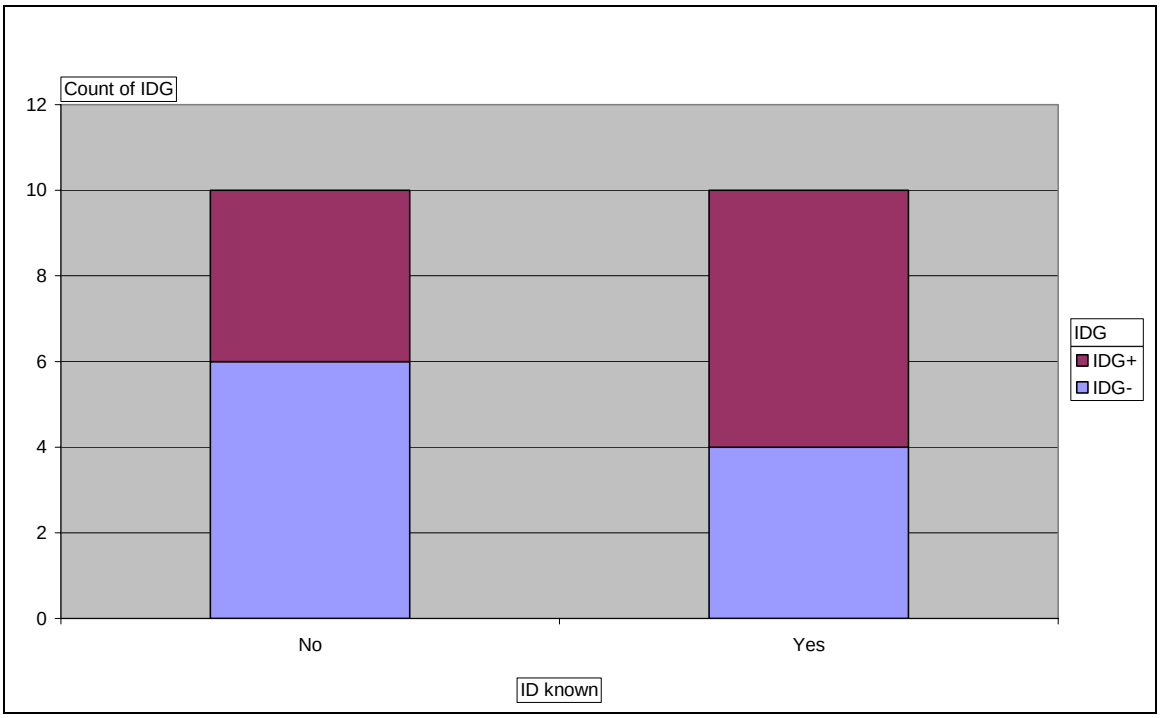

Figure 17. Count of IDG scores identified per knowledge of Instructional Design

Seven participants, representing 35% of the participants reported using an educational model/framework when planning a course:

- BOPPS model - 3 participants
- Bloom's taxonomy - 3 participants
- ADDIE model - 1 participant

Six of these participants were classified as IDG+. More precisely, 4 were IDG+ and M+, 2 were IDG+ and M- and only one was IDG- and M-.

4.2.1. Use of media: rationale, type of course delivery and availability

Several of the comments made by the participants were regarding their own use of media in teaching. For example, for two participants, one of the purposes of using media was to address students' limited attention span and (re-)capture their attention. For other instructors the use of media was a means to make concepts more exciting and to match different types of learning under the general assumption that some students learn better from images while others learn better from text, etc.

During the interviews, it was also acknowledged that the use of media also depends on the type of course delivery (online versus face-to-face) and on the course level (graduate versus undergraduate). Two participants who teach a variety of courses (e.g., face-to-face, online, graduate and undergraduate) mentioned their tendency to use more media for the online courses because “the face time is less available” and that they “can’t pick up visual cues from students” to see whether they understood concepts or not. The difference between undergraduate and graduate courses was also underlined by participants who noted that undergraduate courses need to be more didactic and present more “digested information”.

Some participants’ comments were in relation to the difficulty of finding relevant media for teaching abstract or conceptual topics. One participant, who teaches predominantly technical courses, stated that “videos are good for popular science but the students [in the third and fourth year] are already specialists in that domain and they need formal information”.

These findings resonate with the literature review reminding us of Dale’s cone of experience and suggest that instructors should use media that is specifically from the top of the cone (more abstract) when teaching students with more experience/knowledge such as students in the later years of study or graduate students.

A related comment by another participant, was that “the use of media can get in the way of teaching” because it is time consuming to find and because of the technical difficulties that could arise from using it. The availability of media was a problem also identified by other participants who noted that it tends to become out of date quickly and ends up requiring high level of maintenance to maintain its currency. On a related note, one participant mentioned with regard to finding media that “it is time consuming, but it’s worth it”, while another considered that it may not be worth doing: “if I increase the learning experience of my students by 10% but I have to spend 80% more time to set it up, is it worth it?”

4.2.2. Interaction

One participant admitted to using various types of media and technology (i.e., Twitter[2], YouTube videos[3], blogs, Facebook[4], and podcasts) for the purpose of keeping the students engaged. Other participants mentioned the use of iclicker[5]-type systems for administering quick quizzes and polls during live face-to-face classes. For large class sizes (over 50 students), one participant acknowledged a preference for capturing attention rather than interacting directly with students. On the other hand, another participant who was also teaching large face-to-face classes preferred to keep the interaction in class (i.e., student-instructor, student-student) and believed that large class size is not detrimental to this type of interaction. Seven participants (representing 35% of the total participants) did not use group work (student-student interaction) in their courses. One participant who was teaching a technical course stated that "students should work independently in order to improve their engineering skills". By contrast, one participant who was teaching a Social Science course said that group work is advantageous because student opinions are representations of reality or phenomena and other students would learn from these multiple representations. On a complementary note, one participant who taught Social science courses acknowledged a fourth type of interaction: between a learner and his/her self and consisting of a significant amount of reflection where learners examine who they are and how they are doing by expressing themselves in a very personal-based form of writing.

4.2.3. Instructional design and teaching methods

With regards to course design, one participant who was teaching only online courses stated that "I believe in taking the university to people and properly design courses" while another participant acknowledged that "I do try to think a lot more in terms of how can I convey the content in a way that is meaningful." These statements emphasize the

[2] http://twitter.com/

[3] http://www.youtube.com/

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

[5] http://www.iclicker.com/

concern with properly designing courses in terms of thinking more about teaching methods and appropriate delivery technologies.

Two participants, one who had more than 10 years teaching experience, noted that their course design, including media selection and teaching methods got better over the years mostly because they learned from their own mistakes. One of the relevant statements was: “I was feeling my way through, but it would be nice to be more of a science”. This particular statement resonates with the purpose of this research which aims to help instructors through the process of course planning by making them aware of the connections between media, instructional design and technology. “Science is a ‘we’ and not an ‘I’” said one of the participants.

In conclusion, the literature’s lack of unified definitions and categorization criteria for media types and teaching methods provided the grounds for the development of an ontology which is based on the way humans interact with media (i.e., the way the brain receives and processes information). During this process the term *‘media format’* was redefined to refer to how a medium (plural, media) may be formatted in order to hold information to be transmitted through a sensory channel.

Based on the space-time dimensions criteria, a more appropriate description of media, teaching method and physical support of media is possible. Also the media format allows for characterizing media (e.g., written word, graphic, spoken word) that permits the MA analysis. Although the creation of MA graphs were not part of this study, a coding scheme based on media format allowed for the creation of an objective method of assessment of media usage in a course.

Also the literature’s lack of IDG determined the creation of a list of rules that was used to assess instructors’ knowledge and coverage of IDG.

It is important to underline the importance of the literature review to this study:

- It provided extensive information about instructional design, its theories and models and media selection.

- The lack of unified definitions and examples of media types and teaching methods prompted us to develop an ontology that was based on the way the human brain receives and processes information.
- The lack of instructional design guidelines prompted us to create a list of rules that was used to assess instructors' knowledge and coverage of IDG
- The lack of a method of assessment of instructors' knowledge and coverage of IDG for the course materials prompted us to create an objective method of assessment

In conclusion, this study's importance is not only represented by the answer to the research question (i.e., whether there is a relationship between IDG and media in teaching) but also by the methodology developed (i.e., ontology, media format, objective method of assessment of IDG coverage and objective method of media usage). Although the literature showed that the instructional design process does not start with media selection, this study allows for a new approach: assessing media in relationship to IDG (i.e., the IDG rules covered by each media) will give instructors the opportunity to learn and reflect about IDG. This is extremely useful because the Internet and technology in the twenty-first century allows instructors and learners easy access to various types of media (e.g., video clips, graphics) and sometimes, course design ideas can start with a movie they have seen or a podcast they have heard.

5. Discussion

The aim of this study was to explore the relationship between the use of media in teaching and instructional design. The study was conducted to answer the following research question: “Is there a correlation between the use of media in course materials and the coverage of instructional design guidelines (IDG)?”

The initial objectives of this thesis were:

- to develop a concept and an objective measure that quantifies the use of media (i.e., the media amplitude - MA) in course materials,
- to assess instructors’ use of media in teaching,
- to assess instructors’ awareness and use of IDG, and
- to explore the possible relationship between media and IDG

The time constraints of the research methodology (data collection and analysis) have limited the role of the MA concept which remained a theoretical construct. However, as discussed in the Theories and Models section, human learning is influenced by many factors, such as cognitive, social, emotional, motivational, etc. An increased MA that translates in a higher usage of media in instruction may provide more opportunities to influence learners, to trigger responses from them and to enable the instructor-learner feedback loop.

5.1. IDG development

The literature review provided extensive background information about instructional design theories and models but also revealed a lack of clear and actionable published guidelines for instructional design. In this study, IDG was introduced from a theoretical point of view but applied in the form of a compressed, shorter list of rules (four instead of seven). This was partially the result of the study time constraints (e.g., limited interview time): a shorter IDG list allowed for a more direct and usable approach in assessing instructors’ awareness and usage of IDG. During the interview, the participants were also asked whether they were considering any instructional design principles or rules when planning a course. They were therefore offered the opportunity to add anything else that

they considered important in the course designing process in the context of the fourth item on the adopted IDG rule list (i.e., ‘other’).

5.2. Importance of ontological work

In the general context of continuous advances in information technology, distinguishing between concepts such as media, physical support of media and teaching is difficult without a suitable classification method. While the literature review revealed a multitude of classifications it has also suggested a lack of clarity with regard to the differences between these important concepts. Recognizing the high importance of this ontological work, this research also focused on clarifying and organizing concepts such as media, media format and teaching methods in order to provide a more solid basis for the assessment of the usage of media in teaching. In addition, the reader is reminded that the ontological work involved a definition of the notion of media format that was based on the fundamental principles of information processing in the human brain. The time-space organizational matrix proposed in this thesis (Table 10) which allowed for the categorization of present and possibly of future media, teaching methods or physical supports of media, was created in the hope that it will remain largely independent of technological advances. In my view, this work also represents an important original research piece with high relevance to applied informatics research and with potential for future development.

5.3. Importance of mixed methodological approaches

The mixture of quantitative and qualitative methods was a suitable approach for this study. The information gathered for the qualitative analysis allowed better understanding of the results of the quantitative analysis. For example, the quantitative analysis suggested that the use of media is influenced by the Social Science field, and the qualitative analysis offered a possible explanation for this observation: finding, creating and using media resources for abstract topics generally taught in the field of Natural Science is more difficult.

5.4. Data collection: does online vs. face-to-face method make any difference?

The data collection methodology used in this study was based on interviewing the participants. Some of the interviews were conducted online and some face-to-face. As the interviewer, there was not noticed any difference between the data collected through these two methods. As it was a semi-structured interview, the participants were supposed to answer all the predefined questions so the data gathered for the media and IDG assessment was consistent for each participant. The comments and discussion that were part of the qualitative analysis flowed naturally and some of the participants interviewed online were more talkative than others. This could be attributed not to the medium of communication (online) but to the participants' genuine interest in the subject.

5.5. Self-assessment did not work!

During the interview participants were asked to assess themselves on a 5-point Likert scale with regards to their usage of media and coverage of IDG in their courses. Before asking any interview question, every participant was presented with an introduction to the study and to a definition of important terms (e.g., media, teaching methods, IDG). The self assessment happened in two stages.

1) Media discussion. The discussion was focused on participants' use of media in their course and on the details related to how they were using the media. This allowed the capture of information about media and media formats used as well as information about the teaching and delivery methods used. The discussion was followed by asking participants to self-assess with regard to their use of media in teaching. A discrepancy between the use of media reported in the discussion and the participants' self-assessment was noticed.

2) IDG discussion. This discussion was focused on the way participants think about designing a course and also what steps are taken when planning and organizing a course. The IDG list was brought up on the computer screen where the subjects could see it and they were asked whether they had thought about each IDG rule and what they were doing with regards to the rules. This was followed by asking participants to self-assess with regard to the amount they consider IDG when planning a course. A discrepancy between

their comments with regard to the steps taken when planning a course and the self-assessment score was noticed.

This discrepancy prompted the creation of a more objective method of assessment. By analyzing the qualitative data, it was possible to create an objective mathematical calculation of media and IDG usage. This shows the importance of using a mixture of research methods for this study. If qualitative methods were not used, then the analysis would have been based on the data from self-assessment questions and the results would have been biased.

Literature shows that students' self-assessments have poor accuracy and that their assessments are higher than ones made by a teacher (Tousignant et al. 2002, Ross, 2006). Another study, one that involves physicians who self-assessed their knowledge, shows the same results: lack of correlation between perceived and actual knowledge (Tracey, 1997). The reasons are the independent nature of their work and the low probability of talking to their peers. In addition, the breadth of the medical practice and the rapid pace at which medical knowledge changes make it difficult for a physician to keep up with and notice when updates are needed.

Similar reasons could explain the inaccurate self-assessment in this study. Instructors in university environments are under continuous pressure to publish and to carry out research and as a result, undergraduate teaching may not always be a priority. In addition, university instructors are not required to have any formal teaching training and they may never have a chance to be exposed to a systematic approach to designing and preparing a course. That is probably why some of the participants commented that the more they taught, the better they became at teaching. This reality could be illustrated very clearly by a comment made by a participant who said: "I was feeling my way through, but it would be nice to be more of a science."

Since the self-assessment was found to be problematic, less emphasis should be put on it in a future study and, if possible, only objective measures of assessment should be used. This pilot study demonstrates the feasibility of using the epidemiological methodology in this setting. Broadening this research to include more participants, and including more participants from Natural Science faculties would be useful in the future.

5.6. Development of an objective method of assessment

For the analysis, a more objective method of assessment of media and IDG usage was created. It is very important to remember that even those instructors who were considered M- (media negative) in this study actually do use forms of media. The calculation of total media usage was based on a formula (sum) and the result was a numeric value between 0 and 8. The threshold was set between values of 4 and 5 because of the median distribution of the results. That means that participants who scored up to and including 4 points, were considered M-. The same procedure was applied for the IDG usage calculation. As a result, participants who were IDG- did in fact cover some of the IDG principles. The threshold between values of 4 and 5 for IDG was defined this way because of the median distribution of the results.

In the interviews many participants reported that they had used various types of media such as popular culture videos just to capture students' attention. Although this is an attractive approach in some cases, one may question what would be better: to use less relevant videos solely for capturing attention or to use other types of media such as text and still images that are more relevant to the subject matter.

However, to discuss content matter and relevance to course material falls outside the scope of this research. It is assumed that an instructor possesses and will always exercise judgement when deciding on the relevance of the media content (e.g., topic) to their course material. It is very unlikely that a reasonably simple and automated methodology, even computerized, could be employed to equal an instructor's decision-making power to select and decide on the relevance of material to their courses. The general opinion, which is also reinforced by the literature review, (Gagné et al., 2005, Reigeluth, 1999) is that media should be carefully selected in accordance with the lesson's objective, teaching method, delivery method and technology/equipment needed.

An interesting approach for a future study would be to explore the coverage of IDG for each media for a specific learning objective/topic/lesson. This would show the exact usage of media in covering the IDG and whether or not that specific media is useful to the subject taught or if it could be replaced with a more meaningful or appropriate one.

While these are results from a pilot study with a small sample, the analyses suggests a relationship between the use of media in teaching and IDG that is influenced by years of teaching experience and field of study (i.e., Natural Science, Social Science).

In this study we identified the following types of instructors:

- Instructors who are interested in media and try to use it as much as possible but are not interested in IDG
- Instructors who are interested in IDG but do not manifest a special interest in media
- Instructors who are interested in both media and IDG

It is important to underline the difference between being interested in using media and IDG and actually using media and applying IDG in practice. This study noticed many participants who were interested in the use of media and IDG but who did not necessarily score as IDG+ or M+ in the analysis.

In agreement with the literature review, we consider that planning a course is a process that should tie together instructional design theory/events of instruction, media and technology. There is a close connection between these elements and they should be addressed when developing a course.

Although the literature review showed that course planning does not normally start with media selection, this study revealed an alternative approach that considers instructional design/course planning through the process of media selection. This approach may help instructors who are not familiar with instructional design principles to learn about them during the process of media selection and allow for selecting media in accordance with IDG.

Sometimes instructors' lack of computer expertise will be reflected in less usage of technology and hence less media usage. Future study should also explore participants' knowledge and ability to use various technologies (e.g., video projection in classroom, learning management system) and their influence on the incidence of media use.

In a future study, the data collection and analysis methodology should be different from the one used in this study and should be based on a more automated data collection procedure. The MA calculation is a formal algorithmic approach based on the ontology developed in this pilot that could employed in such a future study. Using the MA calculation approach would allow more precision since it would collect and analyze media and IDG usage for each topic or learning objective. The results could be graphically depicted in the form of MA and IDG charts that would be part of a data collection tool. This tool could be used by instructors and would ideally provide instant graphical feedback with regards to their own use of media and coverage of IDG for any specific topic/learning objective.

To simplify the MA methodology for a general audience, one could also imagine the following analogy to a medical scenario involving a mother who is going to doctor's office with her child who has a medical condition (e.g., a cold). The doctor has extensive knowledge of clinical medicine and biomedical sciences (e.g., anatomy and physiology) that allow him to diagnose and recommend the appropriate therapy for the child's illness. By analogy, the doctor would be the IDG-media specialist in the learning resources department, the parent would be the instructor, the child is one of the courses taught by that instructor and the medical condition might be low social-emotional attractiveness measured by a low value of the media amplitude (MA). The diagnosis support tool (e.g., a media-thermometer) would help determine the MA value and inform about the need for therapy (e.g., the appropriate instructional design approach). In addition, the body of knowledge that allows the hypothetical instructional design "therapy" could be supported by the development of an ontology that provides a shared understanding and agreement of instructional domain concepts and terms. Organizing and formalizing this body of knowledge would be a task that may form the object of an applied informatics research project aimed at supporting the way people design instructional materials.

5.7. Limitations

1. A limitation of this study is represented by the small sample of participants. This is reflected in the stratified analysis which hinged on just 2 key people: one that was Low teaching, M- and IDG+, and one that was High teaching, M+ and IDG-. If either of these

two people had scored differently, then the results would have been different. But the qualitative data gathered provided us with useful information that allowed us to explain some of the results.

2. Another limitation of this study is represented by the fact that the IDG and media assessment of instructors is an overall one. Instructors might actually do better with regards to IDG and/or media use in one course over another of their courses. Future research should assess each of an instructor's courses separately, possibly breaking it down to an assessment of IDG and media per each topic/learning outcome. This would allow a more accurate evaluation and be likely to give more precise results.

3. A third limitation of the study is represented by the limited qualitative methodology that could have employed a more in-depth analysis of the interview data (e.g., using additional codes, determining additional themes). The qualitative methods were employed to complement the quantitative findings. Therefore this study evolved from a quantitative study of multimedia to a mixed approach that explored some qualitative aspects of the relation of multimedia with IDG.

4. The study was also influenced by the biases of the investigator and the choices made when designing the data collection approaches. Once the interview questions had been formulated, the systematic use of the interview data was intended to reduce (but probably not eliminate) the bias of the investigator. However, the selection of questions still reflected the bias of the investigator towards an informatics study and the assumption that diversification of media formats is likely to contribute to better instruction. The qualitative analysis of themes was structured to reduce the investigator's biases in the analysis, but another investigator might have chosen different themes and put different emphasis on the results.

5. The study had a limited scope of investigation of IDG: this was a study of multimedia in relation to IDG, not a study of IDG use and its relation to multimedia. If a study of IDG use is to be conducted in future, other types of qualitative methods could be used: observational anthropology, institutional ethnography, participant observation, action research, etc.

6. Another important limitation of this study is the realization, only at its conclusion, that social-emotional aspects of IDG and multimedia were neglected. In a future study,

the interviews should explore how instructors pay attention to emotions when designing courses and when selecting media and media formats. Student social and emotional engagement via use of social media has become obvious in the past couple of years, but did not play a role in the conceptualization of this study.

In this context, underlining the importance of socio-emotional motivation in the process of learning is essential. It is likely that emotional factors are not only part of the connection between learners and media but also between instructors' use of media and IDG. An instructor who aims at enhancing learners' experience through the use of various types of media may very probably be emotionally involved in the designing process of the course. The emotional engagement of instructors may contribute to enhancing learning experience and may very well translate into learner engagement.

One of the findings of this study was that the use of media is influenced by the Social Science field, and a possible explanation was that is more difficult to find, create and use media resources for abstract topics generally taught in the field of Natural Science. This difficulty might also be related to the perception that the Natural Sciences have less socio-emotional relevance.

Finally, it is important to mention that the IDG principles may shed additional light on the knowledge spectrum and on media usage by highlighting the importance of emotions in education. One of the avenues of future development is to assess options in each of the domains for their contribution to emotional engagement of students and determine the relative emotional significance of face-to-face experiences, synchronous experiences, interactive experiences, attractive physical supports, inspiring media, stimulating media formats, and emotional intensity of sensory channels.

7. During this study the culture of university towards use of media and technology was not taken into account. Some participants might use more media because of the support offered by their university that may enable easy access to various information technologies and media resources. Other research approaches would be needed in order to explore the importance and impact of these enabling aspects.

5.8. Conclusion

The main conclusion of this study is the observation of the existence of a relationship between the use of media in teaching and IDG that is influenced by years of teaching experience and type of specialty. This pilot study shows the feasibility of its methodology, demonstrating that it can be used to explore these topics in future research projects with more participants.

An additional contribution of this project is represented by the creation of a unified set of IDG that was not available in the reviewed literature. The IDG facilitated the assessment of instructors' awareness and use of instructional design in their teaching. This set of guidelines can be used in the future by instructors to inform and guide their media selection process and to encourage them to consider instructional design principles when planning a course.

The literature review showed that planning or designing a course should follow the instructional design principles and models. But the reality is that instructors might not have the time to learn about instructional design or to follow the required steps when planning or redesigning a course. This study shows that exploring instructional design/course planning through the process of media selection is possible and it could be a useful approach at this present time when there is a wealth of information and media availability on the World Wide Web.

Another important contribution of this research lies in the development of the ontology of teaching methods and types of media. Although the literature provided clear definitions of some terms such as media and teaching methods, the criteria that the authors used to differentiate these notions was not clear and led, as a result, to an overlap in the use of terms (e.g., print being considered media by one and a teaching method by another). This study showed a clear method of categorization that used spatial and temporal dimensions. Using this method media, teaching methods, physical support of media and media format can be easily categorized. Its usefulness is also represented by allowing for the categorization of future types of media and/or teaching methods.

An unexpected result was the realization at the end of the study that learners' socio-emotional engagement is very important and even though it is correlated with the use of media, current IDG principles do not explore it in more depth. The power of technology

allows the use of media and implicitly brings powerful emotional experiences into an ordinary classroom. As technology and social media evolve rapidly this is likely to grow in importance in future. Therefore, one future development possibility of this research is to assess learners' emotional response to a variety of teaching methods (e.g., face-to-face lecture versus online) and media (e.g., video versus field trip, social media environments).

Appendices

Appendix A - Media Amplitude (MA) calculation

The description of the MA concept is in relation to the MA calculation and with the MA chart which provide the visual feedback of the results. Intuitively, the MA value is a function of the number of media types used in teaching.

For each topic, the data collected and used in the MA calculation will be in form of 10-dimensional binary patterns of the form $(m_1, m_2, m_3, m_4, m_5, m_6, m_7, m_8, m_9, m_{10})$ that correspond to the combination of the format types used for any particular teaching method t of the n teaching methods for that topic. Each format type m_i will therefore be associated with a number of teaching methods that calculated as $MA(m_i) = \sum_{t=1}^{n} m_{i,t}$ where $1 \le i \le 10$ and is represented as a point on a MA graph (Table 21). The line that connects all the points in the MA chart is the MA graph (Figure 18).

Teaching method t	**Symbols m_1**	**Written words m_2**	**Graphics m_3**	**Objects /people/ living things (visual) m_4**	**Objects /people/ living things (tactile) m_5**	**Tactile Language Systems m_6**	**Spoken words m_7**	**Music m_8**	**Sounds m_9**	**Rare m_{10}**
t_1	0	1	1	0	1		0	1		
t_2	0	1	0	0	0		0	0		
t_3	1	1	1	0	0		0	0		
…										
t_n	0	0	0	0	1		0	0		
$\sum$	1	3	2	0	2		0	1		

Table 21. The basis of calculation of $MA(m_i)$

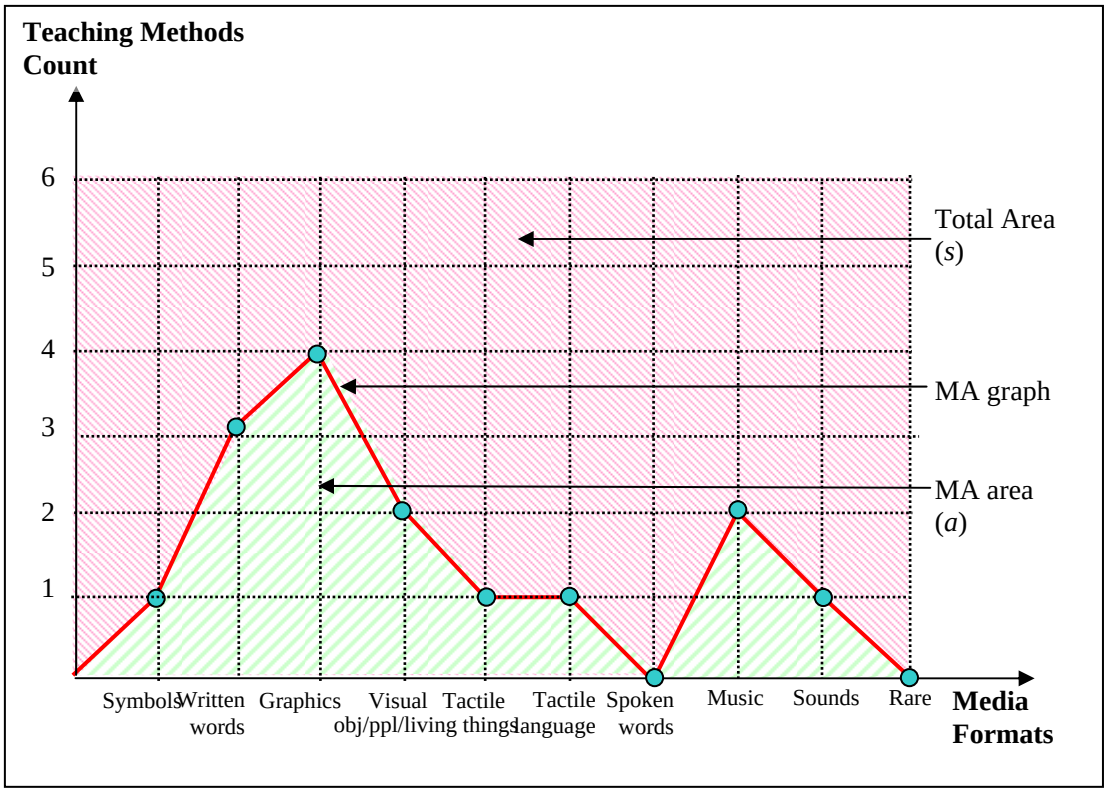

Figure 18. Example of MA chart for one course topic

The MA chart is created for each type of media (in this case the X axis is represented by the types of media and the Y axis by the count of teaching methods). Because an instructor may use one or more teaching methods, the count of teaching methods will be a number between 1 and n. The teaching methods may be associated with any combination of media types.

One can define the area below the media amplitude graph as media amplitude area (a).

If s is the total area of the graph, then

s = total count of teaching methods x 10 (total number of media formats)

We define the MA percentage being the ratio between the area covered by the media formats and the total area of the graph.

MA percentage = $MA = \frac{a}{s} \times 100$

The MA area is independent of the order of the media and format types.

An additional graphical representation was created based on the instructional design guideline (IDG) coverage and represented for each type of media in a similar manner. We refer to this graph as being the instructional design guideline or IDG graph.

For each topic, the data collected and used in the IDG calculation will be in form of 7-dimensional binary patterns of the form $(g_1, g_2, g_3, g_4, g_5, g_6, g_7)$ that correspond to the combination of the IDG covered by any particular teaching method t of the *n* teaching methods for that topic. Each media type g_i will therefore be associated with a number of teaching methods that calculated as $IDG(g_i) = \sum_{t=1}^{n} g_{i,t}$ where $1 \le i \le 7$ and is represented as a point on a IDG graph. The line that connects all the points in the IDG chart is the IDG graph (Figure 19).

One can define the area below the IDG graph as IDG area (b).

If s is the total area of the graph, then
s = total count of teaching methods x 7 (total number of IDG)

We define the IDG percentage being the ratio between the area covered by the IDG and the total area of the graph

IDG percentage = $IDG = \frac{b}{s} \times 100$

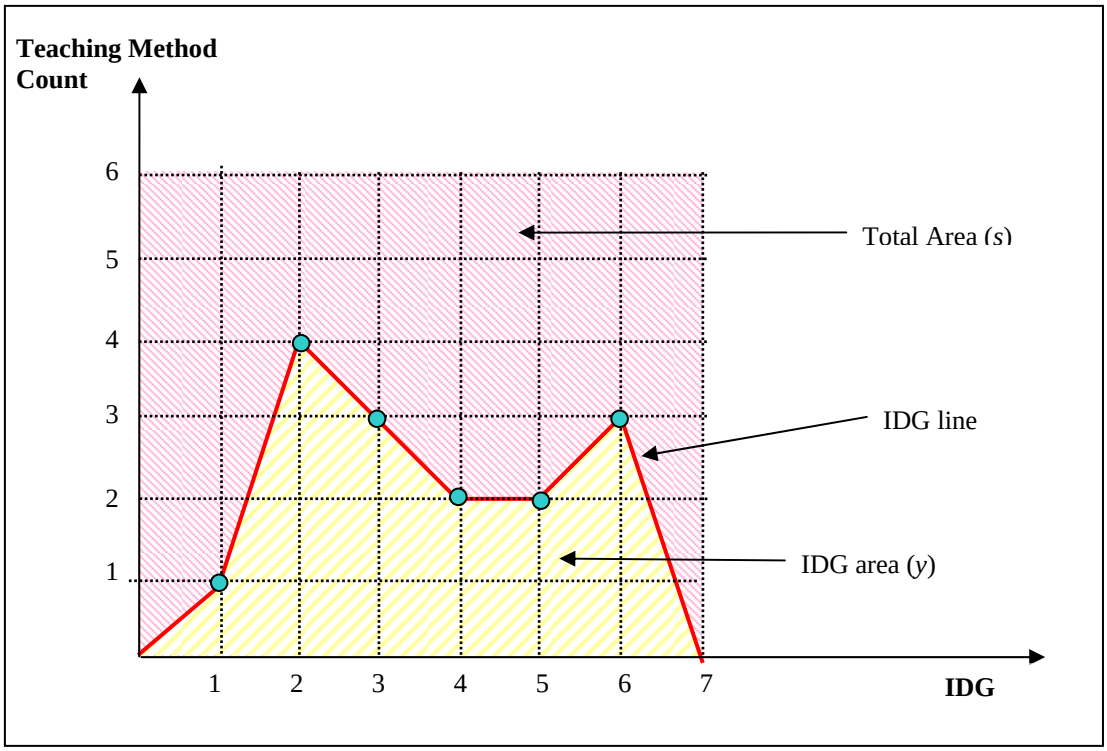

Figure 19. Example of instructional design guideline (IDG) graph

Each topic will have an MA number and IDG number and they will be plotted on a graph. A linear correlation between MA and IDG the graph will result in a straight line (Figure 20). The existence of a correlation would support validity of the MA concept and would enable the estimation of compliance with instructional design guidelines.

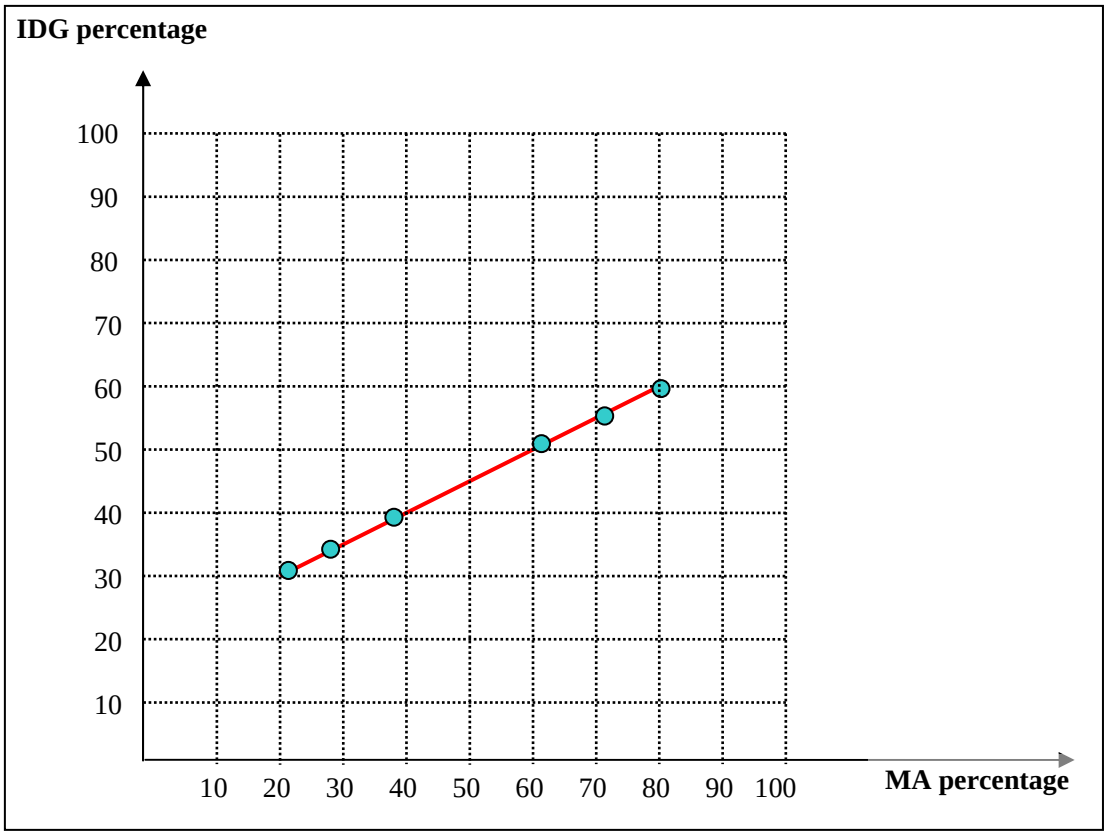

Figure 20. Hypothetical correlation between MA and IDG

Appendix B – Interview slides

Purpose and Objectives

- The purpose of this interview is to discuss about your interest in the use of media in teaching and instructional design.
- The research objectives are:
  1. To develop a concept and an objective measure of the media content of course materials
  2. To assess awareness of Instructional Design Guidelines (IDG)

1

- Teaching methods
  - Lecture, site visit, readings, assignment, group work, meeting/workshop/seminar, experiments, etc.
- Types of media
  - e.g. text, graphics, audio, video, formula, objects
- Interaction
  - e.g. instructor to student, student to student, student with course content
- Instructional Design
  - "Instructional design is concerned with understanding, improving, and applying methods of instruction"

2

Instructional Design Guidelines (IDG)

A. Captures attention, interests, motivates
B. Builds on prior knowledge and/or experience
C. Promotes interaction
D. Other

3

Question 1

1. Do you use media in your courses? In case you do, how do you use it?

- Teaching methods
  - Lecture, site visit, readings, assignment, group work, meeting/workshop/seminar, experiments, etc.
- Types of media
  - text, graphics (pictures, diagrams, videos), audio, objects, formulae
- Interaction
  - Learner - content
  - Learner - instructor
  - Learner - learner

4

Question 1 cont'd

1. On a scale from 1 to 5 how often do you use various types of media in teaching?
   1. Always
   2. Very often
   3. Sometimes
   4. Rarely
   5. Never

5

Question 2

2. How do you think about designing your course? What are the steps that you take to plan and organize your course?

6

Question 2

2. How do you think about designing your course? What are the steps that you take to plan and organize your course?
   - What do you do to capture students' attention?
   - What do you do to build on prior knowledge/experience?
   - What do you do to promote interaction?

7

Question 2 cont'd

2. Based on your own self assessment, how much do you think about IDG when planning a course?
   1. In every course
   2. Most of the courses
   3. Sometimes
   4. Rarely
   5. Never

8

Question 3

3. Do you think there is a potential relationship between using media in your course and your thinking about instructional design?

9

Appendix C – Invitation for participation

Invitation to Participate

(Email)

From: Felicia Pantazi

To: University of Victoria /Conestoga College Instructors

Subject: Invitation to participate in a Master's Study

I am a Master's student in Health Information Science (Distributed Stream program) at University of Victoria, under the supervision of Dr. Malcolm Maclure and Dr. Denis Protti.

The main objective of my Master's thesis is to explore the relationship between media content of a course and instructional design guideline (IDG) in teaching.

I am seeking instructors to be interviewed for discussing about their interest in the use of media in teaching and instructional design.

If you agree to participate, your participation will require being part of an interview with the investigator. During the interview you will be asked questions about:

a. The teaching methods and types of media used in your courses
b. Practices used in designing your courses

The interview will require approximately 20-30 minutes of your time and will be done using a web-conference tool called Elluminate Live or face-to-face and will be recorded.

For more information please find attached the participant consent form. If you agree to participate, please type your name and date at the end of the form and email the completed form to Felicia Pantazi (fpantazi@uvic.ca). In your email message please state that you agree to be part of the study.

If you have any questions, don't hesitate to contact Felicia Pantazi.

Thank you,

Felicia Pantazi, M.D, M.Sc. (candidate)
School of Health Information Science
University of Victoria, B.C., Canada
Email: fpantazi@uvic.ca

Appendix D – Consent form

Participant Consent Form

University of Victoria

HEALTH INFORMATION SCIENCE

An investigation of the relation between media content of a course and instructional design guidelines

You are invited to participate in a study entitled **An investigation of the relation between media content of a course and instructional design guidelines** that is being conducted by **Felicia Pantazi**.

Dr. Felicia Pantazi is a graduate student in the department of Health Information Science at the University of Victoria and you may contact her if you have further questions by email (fpantazi@uvic.ca).

As a graduate student, Dr. Pantazi is required to conduct research as part of the requirements for her Master's degree in Health Information Science. The research is being conducted under the supervision of Dr. Malcolm Maclure and Dr. Denis Protti. You may contact Dr. Malcolm Maclure at (250) - 405-1940 and Dr. Denis Protti at (250) - 721-8814.

Purpose and Objectives of Interview

The purpose of this interview is to motivate interest in instructional design and improve adherence with Instructional Design Guidelines (IDG). However, exploring and applying instructional design concepts requires time and effort and instructors may require additional assistance in developing course materials that comply with IDG.

The research objectives are:

1) To develop a concept and an objective measure of the media content of course materials
2) To assess awareness of IDG
3) To explore the possible relationship between media and IDG.

Importance of this Research

Improvements in adherence with IDG may lead to more effective teaching that benefits both teachers and students.

If a correlation exists between media amplitude and compliance with IDG, then the adherence with IDG could be easily determined, communicated and improved by an analysis of the media amplitude of course materials. This will save the time and effort associated with learning and applying the concepts of instructional design, will improve the adherence with IDG and may lead to more effective teaching.

Participants Selection
You are being asked to participate in this study because you are an instructor at University of Victoria or at Conestoga College.

What is involved

If you agree to voluntarily participate in this research, your participation will consist of an interview. During the interview you will be asked questions about:

1) The teaching methods and types of media used in your courses
2) Practices used in designing your courses

The interview will be conducted via a web-conference tool called Elluminate Live or face-to-face and preferably it will be recorded.

Inconvenience
Participation in this study may cause some inconvenience to you, represented by the time needed to be interviewed (approximately 20-30 minutes).

Risks
There are no known or anticipated risks to you by participating in this research.

Benefits
Participants will gain exposure to IDG. This exposure has the potential to change behaviors with regard to course material development.

Voluntary Participation
Your participation in this research must be completely voluntary. If you do decide to participate, you may withdraw at any time without any consequences or any explanation. If you do withdraw from the study your data will be used only if you give permission.

Researcher's Relationship with Participants
The researcher may have a relationship to potential participants as student/instructor. To help prevent this relationship from influencing your decision to participate, I would ask you to think twice about whether you are being influenced by our relationship, and whether you still wish to participate.

Anonymity
In terms of protecting your anonymity, after data collection all the information that will identify you (e.g. name) will be encoded.

Confidentiality
Your confidentiality and the confidentiality of the data will be protected by archiving the data into password protected files after the data collection process ended.

Dissemination of Results
It is anticipated that the results of this study will be shared with others in the following ways: thesis, thesis or other future scholarly presentations, published articles.

Disposal of Data
Data from this study will be only electronic and will be erased from the School of Health Information Science web server and investigator's personal computer one year after the results have been published.

Contacts
Individuals that may be contacted regarding this study include researcher Felicia Pantazi (fpantazi@uvic.ca).

In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545 or ethics@uvic.ca).

Your name below indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers.

Circle/underline "Yes" below if you agree to be audio have the interview audio recorded.

AUDIO RECORDING: **Yes / No**

If you agree to participate, please type in your name below under "Name of Participant", type in the date, save the form and email it to Felicia Pantazi (fpantazi@uvic.ca) stating that you read this consent and you agree to participate in this study.

_____	_____
Name of Participant	*Date*

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