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The Multimedia Expanse

Students' perceived learning outcome from,
and attitudes toward, multimodal and traditional lectures.

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Abstract

The purpose of this study was to examine students' attitudes toward multimodal presentations (AtMP) and traditional lectures (AtTL). A literature review of current research on this topic suggests that students generally have more positive attitudes toward the former rather than the latter, but few of these studies has a focal point on different study programmes and students within *hard* and *soft* sciences. Similarly, media literacy and technology ambivalence is seldom seen in relation with students' perception of instructional mediums, and the distinction between *methods* and *mediums* seems to be mostly ignored. Set within a Norwegian context and observed through the lens of what Richard Mayer and his colleagues define as the Cognitive Theory of Multimedia Learning, the current study intended to measure whether a relationship existed between students' attitudes toward the two instructional mediums, media literacy and four study programmes (psychology, dentistry, education and medicine).

The study was quantitative in design addressing seven research questions. One hundred and sixty-five students, attending either the university or a university college in Bergen, completed a questionnaire presented during four separate plenary lectures. The attitude scales (AtMP and AtTL), serving as the main instruments in the study, were built upon four items measuring students' perception of the lecture structure, learning outcome, motivation to attend lectures and interaction between students and lecturer when one of the two lecturing mediums were used. Both descriptive and inferential statistics were applied (correlation, one-way analysis of variance and regression). The results indicated a strong negative relationship between AtMP and AtTL, meaning positive attitudes toward one would likely signify negative attitudes toward the other. Medicine students differed significantly from the other study programmes, favouring traditional lectures over multimodal presentations. Furthermore, there was a positive relationship between students' perception of their lecturers' media literacy, didactic awareness and AtMP, though no such relationship was found with AtTL.

Implications of this study suggested that many of the students wish for more complex multimodal presentations in their lectures; moreover, it should not be taken for granted that students are undivided positive toward indiscriminate use of PowerPoint or similar software. The discussion concludes that more research is needed on the actual use of multimodal presentations in Norwegian higher education.

Samandrag

Formålet med denne studien var å undersøke studentar sine haldningar til multimodale presentasjonar (AtMP) og tradisjonell tavleundervising (AtTL). Ein litteraturgjennomgang av forsking innan emnet gjev inntrykk av at studentar generelt har meir positive haldningar til fyrstnemnde framfor sistnemnde, men få av desse studiane tek for seg forskjellige studieprogram og studentar innanfor *harde* og *mjuke* vitskapsfelt. Samstundes vert digital kompetanse og ambivalens knytt til teknologi sjeldan sett i samanheng med studentar si oppfatning av undervisingsmediet, og skiljet mellom *metode* og *medium* vert i stor grad ignorert. Sett i ein norsk kontekst, og vurdert ut frå det Richard Mayer og kollegane hans omtalar som the Cognitive Theory of Multimedia Learning, var studien meint på å måle om det var eit tilhøve mellom studentane sine haldningar til undervisingsmedium, digital kompetanse og fire studieprogram (psykologi, odontologi, pedagogikk og medisin).

Studien hadde eit kvantitativt design og tok for seg sju forskingsspørsmål. Eit hundre og sekstifem studentar, frå anten universitetet eller ein høgskule i Bergen, fullførte eit spørjeskjema som vart presentert i løpet av fire uavhengige forelesingar. Haldningsskalaane (AtMP og AtTL), som utgjorde hovudverktyet i studien, var sett saman av fire element som målte studentane sine oppfatningar av undervisingsstrukturen, læringsutbyttet, motivasjon til å møte på forelesing og interaksjon mellom forelesar og student når eit av to undervisingsmedium vart brukt. Både deskriptiv- og slutningsstatistikk vart nytta (korrelasjon, einvegs variansanalyse og regresjon). Resultata gav indikasjonar på eit sterkt negativt forhold mellom AtMP og AtTL, med andre ord var positive haldningar til eit undervisingsmedium ofte avspegla i negative haldningar til det andre. Medisinstudentane var signifikant forskjellige frå dei andre studentane ved at dei føretrakk tradisjonell tavleundervising framfor multimodale presentasjonar. Samstundes vart det funne eit positivt tilhøve mellom AtMP og studentane si oppfatning av digital kompetanse og didaktisk innsikt hjå førelesarane. Denne relasjonen var ikkje gjeldande for AtTL.

Studien gav indikasjonar på at mange av studentane ynskjer at førelesarar i større grad nyttar seg av komplekse multimodale presentasjonar, og samstundes at det ikkje er naturgitt at studentar er udelt positive til ukritisk bruk av PowerPoint eller liknande programvare. Diskusjonen avsluttast med ei tilråding om meir forsking på den faktiske bruken av multimodale presentasjonar innan høgare utdanning i Noreg.

Acknowledgements

"Genügt ein Geist für tausend Hände" (One mind is enough for a thousand hands)

~ Johann Wolfgang von Goethe (1832/2010, p. 258).

Though not truly aligned with Faust's sentiment, I've often found his words mirroring my own feelings toward this current study. The hundred and sixty-five minds, the base for my thesis, have left me one hundred sixty-four thousand, nine hundred ninety-eight hands short. Poor paraphrasing (and ridiculous numbers) aside, I only hope that the small partitions I've salvaged from the original meanings are offered in a sound and respectful manner, somewhat resembling their point of origin.

I wish to thank my supervisor, Professor Krumsvik, who without his guidance and crucial contributions this study would not have been feasible. I'm also grateful to Dr. Bøyum**,** Dr. Søreide and Dr. Westrheim who (among others) saw me mostly unscathed through the first year of the M.Ed. The same goes for my fellow students, thank you!

It will become quite clear for anyone who read this thesis, and I will not deny the fact, that the most important aspect for me has been to explore the rudiments of quantitative methodology. I have not learned enough, but I do believe I've learned some, and I would therefore like to thank Professor Andy Field for his excellent book, *Discovering statistics using SPSS: (and sex and drugs and rock 'n' roll)*, in addition to his truly bizarre webpage (www.statisticshell.com). I've been fascinated by inferential statistics, but I've never believed it to be entertaining. Up the Irons!

Lastly, but not least, I would like to thank the respondents for their contribution and the lecturers who let me occupy their auditoriums and bother their students. I'm in your debt.

Øystein Olav Skaar

Bergen, March 2013

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List of Abbreviations

AtMP	Students' attitude toward Multimodal Presentations
AtTL	Students' attitude toward Traditional Lectures
CTML	Cognitive Theory of Multimedia Learning
CLT	Cognitive Load Theory
(E)FA	(Exploratory) Factor Analysis
PAF	Principal Axis Factoring
SMC	Squared Multiple Correlations
RQ	Research Question
ICT	Information and Communications Technology
NOU	Norway Opening Universities (Norgesuniversitetet)
ONR	Official Norwegian Reports (Noregs offentlege utgreiingar)
DLC	Digital Learning Communities Research Group

1. Introduction

It has been estimated that at the dawn of this third millennium CE, just within its 25th birthday, Microsoft PowerPoint recorded its one billionth installation on a computer or Macintosh somewhere on this planet (Parks, 2012). With over ten billion presentations held each year, the presence of PowerPoint is almost ubiquitous (Savoy, Proctor, & Salvendy, 2009). Nevertheless, though the presentation software has become so popular it needs no further introduction, there is still a debate regarding whether it truly is a beneficiary contribution to the science of education (Doumont, 2005; Tufte, 2006).

Edward Tufte (2006) is among the foremost critics of PowerPoint, and claims the software is a tool for the nervous speaker rather than a satisfactory medium for delivering educational content. Due to the software's inherent low resolution, hierarchical layout and the large typefaces required for rendering viable text, there is limited space available for on-screen content. The implication being that long presentations necessitates several slides, and Tufte (2006) states this makes it challenging to understand and evaluate the relationship between contents on different frames. Furthermore, the built in multimedia opportunities in PowerPoint may lead to the temptation to fill in vacant space with colourful backgrounds and lively animations. Tufte names these *PowerPointPhluff*, and states "[t]hin content leads to boring presentations. To make them unboring, PowerPointPhluff is added, damaging the content, making the presentation even more boring, requiring more Phluff…" (p. 15).

Jean-Luc Doumont (2005) responds to Tufte's claim that *PowerPoint is Evil* by pointing out that there is a difference between the production tool and the product. Still, he agrees that many multimodal presentations are indeed ineffective, often involving written and spoken parts that are co-dependent on the other. Doumont is especially incredulous to presentations equalling a wall of text, since verbal information needs to be processed sequentially, thus forcing the audience to either read the text or listen to the speaker (Doumont, 2005, p. 65). Furthermore, Doumont argues graphs are a good alternative to text and may foster learning on an alternate level, since graphs do not contest for the same resources as written and spoken text.

Both Tufte and Doumont present arguments shared by Richard Mayer's (2009) Cognitive Theory of Multimedia Learning (CTML). PowerPointPhluff is redundant and irrelevant information and Mayer would define these as seductive or decorative pictures, and depending on their level of interest, PowerPointPhluff could possibly inhibit learning outcome. Moreover, Tufte claims interconnected information that is presented on different slides increases cognitive load, and this is a vital part of what Mayer calls the temporal contiguity principle (Mayer, 2005b). Using graphs or graphics instead of written text could be described as the multimedia principle, which states one learns better from words and pictures than from words alone (Mayer, 2009). Adding graphs while using spoken text instead of written text adds to what CTML defines as the modality principle. Doumont also touches upon an important assumption of CTML, *the dual-coding theory*, which posits that verbal and nonverbal information can to some extent be processed simultaneously since they are contingent on two independent cognitive systems (Paivio, 1986, p. 53). Mayer's CTML will be further examined in chapter two.

1.1. Problem Statement and Significance of Study

Though Mayer asserts multimedia, or the use of words and pictures, leads to better learning, he does not claim that PowerPoint or other multimodal presentation software is better than traditional mediums. Indeed, multimedia instruction is possible in low-tech settings like traditional *chalk and talk* (Mayer, 2009, p. 5). There are several studies (Apperson, Laws, & Scepansky, 2006; Conole, de Laat, Dillon, & Darby, 2008; Corbeil, 2007; Susskind, 2005) indicating that students prefer PowerPoint (i.e., multimodal presentation software) over traditional lectures (i.e., chalk and talk), but there is little evidence that the former fosters better learning outcome. Some studies even point to the opposite, though the students still favoured multimodal presentations (Amare, 2006; Savoy et al., 2009). One could therefore ask, why implement interesting, but otherwise fruitless and expensive equipment in every auditorium?

One answer may be practicality. Some would say the researcher behind this study belongs to a new strain of humans dubbed *digital natives*, originating from the technology enhanced era after 1980 (Ng, 2012; Palfrey & Gasser, 2008; Prensky, 2001a). As an older representative of the species, I remember with bemusement the early days, the large TVs with small screens, bad video machines and even worse videotapes, the immensely hot overhead projectors and the poorly constructed devices indented to transport these monstrosities around. But still, practicality is only practical when one has the competence to take advantage of the intrinsic possibilities of the proposed opportunities. Information and Communications Technology (ICT) offers many possibilities, but they are all for naught without the required competence, the media literacy needed to manoeuvre between the multifarious layers of the digital world. As such, it is necessary to define media literacy and its implication for both lecturers and students.

The term media literacy is preferred over common equivalents (e.g., digital literacy and ICT competence), based on the reasoning of Ola Erstad (2010). Likewise, the study adopts Colin Lankshear and Michele Knobel (2011, p. 33) definition of literacy as “socially recognized ways in which people generate, communicate, and negotiate meanings, as members of Discourses, through the medium of encoded texts”. Thus, one could argue there are many forms of literacies for various discourses (i.e., contexts) each having their socially recognized (i.e., practiced) ways (Lankshear & Knobel, 2011, p. 50). Media literacies encompass analogue, digital, and mediums yet to come, and is therefore detached from current technologies. As such, it may save the researcher from utter embarrassment when future anthropologists mentally project this thesis through some sort of organic innovation.

Reports surrounding media literacy, multimedia learning and the use of ICT in higher education is a recurring topic in the Norwegian media (Eikeseth, 2013; Hammerstad, 2011; Mostad, 2012; Studvest, 2011; Sætra, 2012, 2013) and public documents (Meld. St. 23 (2012–2013); St.meld. nr. 19 (2008-2009)). However, regardless of their intentions, these statements and opinions often lack empirical and theoretical foundation (Krumsvik, 2009; Krumsvik & Ludvigsen, 2012; Official Norwegian Reports 2013:2; Torgersen, 2012). Many of the digital natives are now adults, stepping into occupations involving teaching and education, and if one assumes the *digital immigrants* (i.e., people born before 1980) to some extent can learn media literacy, the transgression to a digital educational era should be a matter of time and resources. But, different literacies require different sets of skills. Whereas browsing through Facebook only demands basic digital abilities, building complex models in C or other program languages necessitate high digital awareness and competence (Krumsvik, 2012). Moreover, the media literacies needed for an instructor surpass those found among most common occupations and among the general population (Krumsvik, 2012). Rune Johan Krumsvik defines media literacy, or more specifically, digital literacy within an educational discourse, as the “teacher’s ability to use ICT in a professional context with good pedagogic-didactic judgement and his/her awareness of its implications on learning strategies and on the digital Bildung of pupils” (Krumsvik, 2009, p. 177). The definition is based on a digital competence model devolved by Krumsvik, which in a recent study conducted on teachers from upper secondary education (n = 2579) demonstrated to be both theoretical and empirical robust (Krumsvik, 2013).

Are such literacies innate among people born after 1980, and is there such a thing as digital natives? Marc Prensky (2001b, p. 1) states the brains of digital natives “are likely *physically different* as a result of the digital input they received growing up”. However, there are reasons to doubt Prensky’s claim (Bennett, Maton, & Kervin, 2008; Brown & Czerniewicz, 2010; Helsper & Eynon, 2010). Norway has a high density of technology, and higher education institutes emphasises the use of digital tools and digital infrastructure, yet there is a lack of attention on media literacy, and there are still many among both the digital immigrants and natives who lack basic ICT skills (Official Norwegian Reports 2013:2, p. 99). Some of these differences are likely caused by socioeconomic variables (Erstad, 2010; Guthu & Holm, 2010; Krumsvik, 2008), and studies have shown the term digital natives is probably an oversimplification of a digital Zeitgeist found in what Erstad (2010) calls the digital generation (Keengwe, 2007; Margaryan, Littlejohn, & Vojt, 2011). Finally, a homogenous population of young and highly skilled media literates is perhaps no more than a myth, and so it is concerning that “[...] there is a dearth of empirical research concerning students’ perceptions regarding the use of technologies and on the technology’s ability to promote learning” (Tang & Austin, 2009, p. 13).

Hence, the thesis herein presented intends to reconnoitre this theme and review a selection of Norwegian students’ attitudes toward, and perceived learning outcome from PowerPoint (i.e., multimodal presentation software) and chalk and talk (i.e., traditional lectures).

1.2. Purpose of Study

The initiative for this study was (1) to explore if a relationship exists between reported student notion of their own and their lecturers’ media literacy, students’ perception of their lecturers’ didactical awareness and the students’ attitude toward multimodal presentations (AtMP) and traditional lectures (AtTL); to investigate whether there are differences in AtMP and AtTL between study programmes (psychology, dentistry, education and medicine), grade average from upper secondary education and across gender in different age groups; (2) to examine whether study programmes would be able to predict AtMP and AtTL; (3) and to detect if AtMP could predict students' standpoint regarding the multimedia, modality, temporal contiguity and signaling principles within Mayer's (2009) CTML.

Seven research questions were postulated with intent to resolve this purpose statement.

1.3. Research Questions

RQ1: What relationship exists, if any, between students' AtMP/AtTL and reported student and lecturers' media literacy and students' understanding of their lecturers' didactical awareness?

RQ2: Is there a significant difference in students' AtMP/AtTL between study programmes, grade average from upper secondary education and across gender in different age groups?

RQ3: Are the study programmes able to predict a significant amount of the variance in students' AtMP/AtTL?

RQ4: If controlled for the possible effect of variables from RQ1 and RQ2 will study programme be able to predict a significant amount of the variance in students' AtMP/AtTL?

RQ5: What relationship exists, if any, between students' AtMP and students' standpoint regarding the multimedia, modality, temporal contiguity and signaling principle?

RQ6: Can AtMP predict a significant amount of the variance in students' standpoint regarding the CTML principles?

RQ7: If controlled for the possible effect of variables from RQ1 and RQ2 will AtMP be able to predict a significant amount of the variance in students' standpoint regarding the CTML principles?

1.4. Organization of Study

The thesis is written as a monograph in APA style (6^{th} edition), with some minor alterations in accordance with traditions at the Department of Education (e.g., three centimetre left and right margins and one and a half line-spacing). The opening chapter is meant to give an overview of the study, with a focal point on its purpose and the research questions that has guided the process. Chapter two provides literature describing the cognitive theories used to interpret the data. Chapter three describes the methodology used, including demographical characteristics, instruments and apparatus, the methods of data collection and the data analyses procedures. Chapter four outlines the descriptive and inferential results, whereas Chapter five offers a discussion of the findings within a CTML frame of reference, including their implications and limitations.

2. Literature Review

The purpose of this chapter is to provide an overview of Mayer's (2009) Cognitive Theory of Multimedia Learning (CTML), which serves as a theoretical framework for the study. The literature used was collected through the databases of *JSTOR*, *ScienceDirect* (*Elsevier*) and *ERIC* (*OCLC*), with *Google Scholar* as an additional supplement. The initial search process involved the keywords: *digital literacy, digital competence, digital divide*, *students' perception* and *students' attitude* joined with various combinations of *educational technology*, *chalk and talk, blackboard* and *PowerPoint*, whereas the second phase entailed focus on *CTML* and *Cognitive Load Theory* (CLT). Both search phases were limited to peer reviewed articles in the period from 2009 – 2013. Since, a majority of the search results involved Learning Management Systems (LMS), it was decided to exclude keywords involving *online community, online environment, LMS, distance education, online formative assessment and web 2.0* from the search alternatives (see Appendix C-1). The term limitations were deemed necessary, both as a preliminary quality assessment and as a consequence of the fast-paced evolution of multimodal technology. Moreover, frequent citied and original work was gathered through the reference list in prominent search findings.

The search process revealed an abundance of literature on the topics of CTML and CLT, highlighted by the works of Mayer and John Sweller. Less could be said for empirical studies on digital literacy and students' attitudes toward instructional mediums in plenary lectures. The following sections are not meant to give an extensive insight in the science of learning and instruction; the focal point is rather to add a context for the thesis. The term *cognitive* is probably best known as a derivative of René Descartes (1644/1985, p. 417) proposition, "cogito, ergo sum" (I think, therefore I am) and refers to "the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses" (Cognition, n.d.). *Cognitive science* could be described as the endeavour to combine interdisciplinary perspectives and studies (e.g., computer science, neuroscience, psychology and education) in order to chart the mental processes of the mind (Friedenberg & Silverman, 2012; Hunt, 1989). In light of this, what is CTML?

2.1. Cognitive Theory of Multimedia Learning

Mayer (2009, p. 3) defines multimedia learning as the building of coherent mental representations from words (i.e., printed and spoken words) and pictures (e.g., illustrations, diagrams, animation or videos), whereas CTML "rests on the premise that learners can better understand an explanation when it is presented in words and pictures than when it is presented in words alone". A coherent mental representation, or *mental model*, represents important aspects and associations of perceived information (Mayer, 2009, p. 68). *Multimedia* in its broadest sense refers to the usage of more than one medium (e.g., audio, video, text and graphics) to convey information from a sender to one or more recipients (R. E. Clark & Feldon, 2005). The term multimedia differs from the similar sounding *multimodal* (e.g., verbal and non-verbal), and to confuse matters more the term modal or mode differs from sensory *modality*, meaning the sense system (e.g., visual or auditory) used to receive the information (Moreno & Mayer, 2007). Thus, the term *unimodal*, as used in this study, refers to the sole use of oral and/or written text. Figure 1 illustrates a basic example of multimedia instruction, as portrayed in a common IKEA manual.

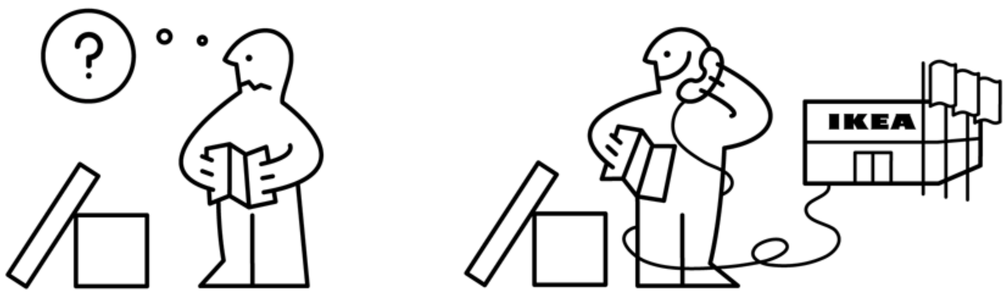

Figure 1. This is multimedia (IKEA, 2006).

Originating in CTML, Mayer has developed a series of evidence-based principles (Issa et al., 2013), in which the *multimedia, modality, temporal contiguity and signaling* principles will be described in section 2.1.2. Moreover, CTML is grounded in three cognitive theories (Mayer & Moreno, 1998, 2003): (1) *the dual-channel assumption* (J. M. Clark & Paivio, 1991; Paivio, 1986), (2) *the limited-capacity assumption* (Baddeley, 1986, 1992; Sweller, 1988, 1989, 1994) and (3) *the active-processing assumption* (Mayer, 1996; Wittrock, 1989, 1992). In the following section these theories will be outlined and explained on the basis of the flowchart depicted bellow (cf., Mayer, 2010a, p. 545).

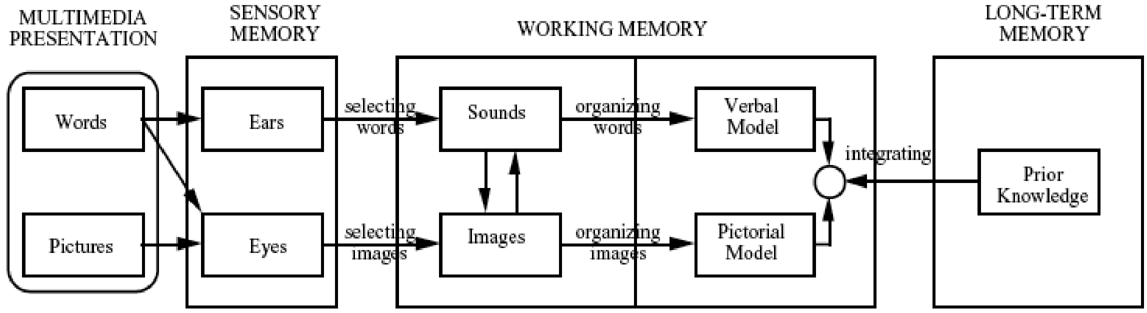

Figure 2. Cognitive Theory of Multimedia Learning (Mayer, 2009).

2.1.1. Dual-coding, cognitive load and generative learning. The main argument in Allan Paivio's theory is that human cognition consists of two separate information-processing systems. The two systems may work independently from each other and they recall, recognise and process verbal representations (e.g., written and oral text) and non-verbal representations (e.g., images and environmental sounds) in the working memory from either the long-term or sensory memory (J. M. Clark & Paivio, 1991, p. 151). Paivio (1986, p. 201) claims performance tied with for instance problem solving, concept attainment and creativity is "mediated by the joint activity of verbal and non-verbal systems, with the relative contribution of each system depending on characteristics of the task and cognitive abilities and habits of the performer". Hence, the dual-systems are independent, but also additive and complimentary, meaning information is processed in one system, but can be transferred to the other when required. (Paivio, 1986, p. 147). Alan Baddeley's model of the working memory is both complimentary and divergent in regards to the dual-coding theory. Working memory is here defined as "a system for the temporary holding and manipulation of information during the performance of a range of cognitive tasks such as comprehension, learning and reasoning" (Baddeley, 1986, p. 34). The key difference lies in how information is processed, and where Paivio emphasises the nature of the stimuli, whether the information is verbal and non-verbal in their respective sensory forms (Sadoski & Paivio, 2013), Baddeley focuses on the sensory input through *the visuospatial sketchpad* and *the phonological loop* (Baddeley & Hitch, 1974, p. 77). According to Mayer (2009, p. 208) written text will first be processed in the former, whereas oral text is always processed in the latter. The two systems are supervised by the central executive, which serves as an attentional controller and coordinates information from one or more systems (Baddeley, 1986, p. 225). It has also been purposed a potential third subsystem, *the episodic buffer*, which conceptually serves as a temporary interface to integrate information from the (two) other slave systems and the long-term memory (Baddeley, 2007, p. 148). Baddeley (1986, p. 76) states the overarching executive and the two slave systems have limited capacity, implying that a single system will have severe difficulty in handling more than task at any given time. Conversely, if the tasks are separated and each steered through either the visuospatial sketchpad or the phonological loop, it is feasible to simultaneously process each input as adequately as one could have done consecutively (Pearson, Logie, & Gilhooly, 1999; Robbins et al., 1996; Sombatteera & Kalyuga, 2012).

Mayer (2009, p. 65) writes that CTML attempts to incorporate and reconcile the two theories, though he notes continuing research is needed to assess the relationship between them. As can be seen from Figure 2, the left side of the working memory illustrates Baddeley's notion of a visual and auditory processor, which based on the instructions of the central executive selects words and images for processing. Mayer (2009) asserts information may then be organized, either independently in each channel or transferred and recoded in the other (e.g., a picture of an apple gets recoded into its verbal form), and subsequently reassigned to the right part of the working memory which represents Paivio's dual-system with a verbal and a non-verbal (pictorial) mode. It should be noted that the left and right part of the working memory, as depicted in the aforementioned figure, do not represent physical parts of the brain.

John Sweller's (Sweller, Ayres, & Kalyuga, 2011, p. 35) theory of cognitive load (CLT) does not "postulate nor need an independent central executive". Instead it is assumed the long-term memory serves as a schematic bank, containing stored information that directs the focus of the learner on the basis of pre-existing schemas (Sweller, 2005). In other words, it is easier to perceive elements that are similar, rather than novel to prior experience and knowledge. This can be interpreted as *the information store principle*, and is the first of five principles in which cognitive load theory is founded on (Sweller et al., 2011, p. 16). The second is *the borrowing and reorganizing principle*, meaning it is assumed that we learn mainly through replicating information from the long-term memory of others, but also that the process is inaccurate, which leads to random changes. Thirdly, *the randomness as genesis principle* entails that new knowledge can only be attained through either unintended random effects of the second principle or, if prior knowledge is otherwise unobtainable, through problem-solving by trial and error (i.e., testing the outcome of randomly generated moves). *The narrow limits of change principle* is the fourth, and deals with working memory and its limited capacity of processing novel information from the borrowing and randomness as genesis principle. According to CLT, meaningful learning is a combinatorial and incremental process of building schemas (cf., coherent mental representations), and the working memory is therefore limited in both capacity and duration to reduce a hypothetical infinite number of random generated moves (e.g., combination of sensory impressions). Thus, the ability of the working memory is restricted to process a finite amount of new information at short intervals to prevent combinatorial explosion (i.e., indiscriminate and infinite solutions). Lastly, there is *the environment organising and linking principle* which states that the former principle applies only to novel information, meaning the working memory can process vast amounts of familiar knowledge produced from the long-term memory. Sweller (2006, p. 355) writes, "[t]his principle permits us to function and act in our environment".

Additionally, Mayer states both CTML and CLT assumes a triarchic model of cognitive load (Mayer, 2009, p. 79). The first of these is *intrinsic cognitive load*, which equals the intellectual complexity of the subject to be learned. That is, the degree of load tied with the amount of individual elements of information that has to be selected in order to organize and build a mental model (Wong, Leahy, Marcus, & Sweller, 2012). From Figure 2 intrinsic cognitive load is mainly identified by the arrows (i.e., selecting words or images) from the sensory memory to the left part of the working memory. According to Mayer (2010a), can overload of this factor lead to rote learning, presented by good retention, but poor transfer performance, if the capacity of working memory is depleted before the information can thoroughly be organized and integrated with the long-term memory. While a retention test usually measures what the learner remembers of the presented material, the transfer test is meant to assess whether the leaner understands it by measuring the learners ability to apply the information in new situations (Mayer, 1996).

In contrast, *extraneous cognitive load* is not dependent on the subject to be learned, but rather on the manner in which it is presented (e.g., poor/good design and redundant/concise material). An extreme consequence of extraneous cognitive overload is the state of no learning, or even learning of stimulating, but in the end irrelevant information, resulting in both poor retention and transfer performance.

Krista E. DeLeeuw and Mayer (2008) claim to find support for a third element, *germane cognitive load*, defined as deep cognitive processing where relevant information is selected, organized and fully integrated with long-term memory. Germane cognitive load depends on active-processing (e.g., motivation), prior knowledge and support during the lesson. However, the claim is not universally accepted, and as Ton de Jong (2010, p. 111) puts it, "[i]f intrinsic load and germane load are defined in terms of relatively similar learning processes, the difference between the two seems to be very much a matter of degree, and possibly non-existent". Indeed, de Jong (2010) and Slava Kalyuga (2011) note that germane cognitive load was first introduced to CLT at a later stage as a theoretical concept (cf., Paas & Van Merriënboer, 1994; Sweller, Van Merriënboer, & Paas, 1998), and recent publications seems to indicate that Sweller opts for a solution where germane cognitive load is seen as a dependent part of intrinsic cognitive load (Sweller, 2010; Sweller et al., 2011; Wong et al., 2012). In a short retort, Mayer (2010b) argues that the distinction between the two load factors is useful as it separates the inherit complexity of the material from the motivation of the learner. Whereas intrinsic cognitive load is an essential part of learning and cannot be modified beyond adapting the subject into obtainable segments (cf., Vygotsky, 1978, p. 87), most of the traditional research on CTML and CLT aims at discovering techniques for reducing extraneous cognitive load (Mayer, 2009; Wong et al., 2012).

The final assumption in CTML is the active-processing principle, which could be seen as an extension and embodiment of the generative learning theory by Merlin C. Wittrock (1974a, 1974b). Wittrock (1992) asserts that generative learning depends on:

> (a) learning processes, such as attention; (b) motivational processes, such as attribution and interests; (c) knowledge creation processes, such as preconceptions, concepts, and beliefs; and (d) most importantly, the processes of generation, including analogies, metaphors, and summaries. (p. 532)

Thus, the active-processing principle differs from notions that the learner is a passive recipient of knowledge (e.g., Locke's *tabula rasa*). Instead, learning is the outcome of cognitive processes that are both constructive and regenerative (Fletcher & Tobias, 2005). Mayer (2010a) states generative, meaningful learning, as depicted in Figure 2 is the result of processes involving *selection* and transferal of relevant information from the sensory memory store (e.g., eyes and ears) to the working memory, where it is *organized* and connected with other verbal and visual impressions into a coherent mental structure, and finally *integrated* with the long-term memory (i.e., prior knowledge) leading to a deep understanding of the material (Mayer, 2011b; Mayer, Fennell, Farmer, & Campbell, 2004; Mayer & Wittrock, 2006). The mental representations, or structures, can be constructed in different ways, though Mayer (2009, p. 68) list five major types: (1) *process* (e.g., flowchart over a cause-and-effect chain); (2) *comparison* (e.g., matrix of attributes between two or more elements); (3) *generalization* (e.g., mind map of the relationship between elements); (4) *enumeration* (e.g., a list of elements) and (5) *classification* (e.g., hierarchy over elements in a system). In order to establish such structures the learner must actively engage in cognitive processing during learning, but Mayer (2005, p. 38) point outs the cognitive system is not necessarily linear, and the learner might move back and forth from the various processes in numerous ways.

2.1.2. Principles of multimedia learning. The preceding section gave an outline of how people learn through what Mayer describes as the *science of learning* (Mayer, 2008). A key aspect of this study was to assess students’ attitude toward multimodal presentations and traditional lectures. These are *instructional mediums*, physical devices designed for delivering content, but tell nothing of the *instructional method* used (Mayer et al., 2009, p. 53). The latter encompass techniques to stimulate the cognitive processes described in the previous section, and a theorem of CTML states that methods cause learning, whereas mediums does not (R. E. Clark & Feldon, 2005; Moreno, 2006). The *science of instruction*, or how to help people learn, exemplified through four CTML principles will be the focal point of this section.

In the introduction to *Multimedia Learning*, Mayer (2009, p. 25) writes CTML aspire to achieve two goals, contribute to the science of learning and to instructional practice by developing theory-grounded and evidence-based multimedia principles (i.e., use-inspired basic research). Mayer (2010a, p. 547) states there are three major instructional goals in accordance with the three types of cognitive loads presented in Sweller’s cognitive load theory. These are to manage *essential processing* during intrinsic cognitive load, reduce *extraneous processing* during extraneous cognitive load and foster *generative processing* under germane cognitive load. The four CTML principles covered in this study are designed to regulate these processes.

As a source for the other principles, and at the very core of CTML, lies the *multimedia principle,* which states that one learn more deeply from words and pictures than from words alone (Mariano, Doolittle, & Hicks, 2009, p. 244). CTML assumes verbal and non-verbal representations are qualitatively different, and though words and graphics may complement one another and even describe the same phenomenon, “the resulting verbal and pictorial representations are not informationally equivalent” (Mayer, 2009, p. 227). The theoretical rationale for this notion could be explained from generative processing and on the basis of the dual-channel assumption depicted in Figure 2. Mayer (2009) claims instructors who only use words loses an opportunity to foster learning, as the information is (mostly) channelled through the verbal part of the working memory and therefore neglects the pictorial model.

Furthermore, the generative assumption implies that motivation is a key factor for integrating coherent pictorial and verbal representations, and by using words and pictures the instructors may both motivate the learner and make these connections easier. Empirical data supporting the multimedia principle are numerous, but while pictures may foster motivational interest, it does not necessarily improve retention or transfer performance (Fletcher & Tobias, 2005; Moreno & Valdez, 2005; Tangen et al., 2011). Eunmo Sung and Mayer (2012) addresses three kinds of graphical types, where *instructive* pictures are relevant to the learning material, *seductive* pictures are highly interesting but not directly relevant to the learning material and *decorative* pictures are neutral, or less-interesting, pictures that are not directly relevant to the learning material (i.e., PowerPointPhluff). The results of their study indicated that the students liked all three forms of pictures equally, regardless if they were redundant or not. However, adding seductive graphic had a negative effect on their retention performance, whereas decorative graphics had no impact when compared to a no-graphics group. Conversely, the instructive picture group outperformed all groups, mimicking the results of Jason M. Tangen et al. (2011).

Where the multimedia principle is meant to foster generative processes, the *modality* principle is adapted for managing essential processing. Mayer (2005a) asserts that one learn better from pictures and oral text than from pictures and printed text. By using Figure 2 and Baddeley’s (1992) theory of working memory, one may explain the theoretical rationale for this assumption. Printed text and pictures are similar in that they have to be first perceived by the eyes and then processed in the visuospatial sketchpad.

By itself this may cause cognitive overload, but the modality principle adds another beneficiary to learning besides removing cumbersome text. By changing modality from visual to auditory, verbal information will be en route directly from the ears to the phonological loop and subsequently, the verbal model of the working memory. Thus, more resources are freed for pictorial processing (Low & Sweller, 2005). Mayer (2009, p. 215) claims the modality principle has the greatest empirical support of the CTML principles, but in a meta-analysis of Joachim Reinwein (2012) questions are raised about Mayer's interpretation of Baddeley's theory. Reinwein (2012, p. 28) states that, oral and written text are both processed in the phonological loop, where written text first is recoded by silent articulation, hence, "Baddeley's model cannot be used to explain the modality effect" (cf., Jones, Macken, & Nicholls, 2004; Tabbers 2002). Though this does not discredit the principle as a whole, it augments the impression that the relationship between the slave systems in the working memory needs further research.

The *temporal contiguity principle* aims at reducing extraneous processing, and according to Roxana Moreno and Mayer (1999) the principle entails that one learns deeper when words and pictures are temporally synchronized, meaning when they are presented simultaneously rather than successively. A criterion is logically that the portions are high in element interactivity, thus, incomprehensible by themselves. The theoretical rationale follows the lines of CLT and the narrow limits of change principle, that is, the working memory's' limited capacity to process novel information from the sensory memory. When time between disparate but related portions of information is reduced one is likely more able to process and connect the various visual and verbal impressions, and thereby build coherent mental representations (Mayer, 2009). In a meta-analysis of 50 experimental studies, Paul Ginns (2006) claims to find support for the principle, but notes the importance of the adjacent relationship between *time* (temporal contiguity principle) and her twin sister *space* (spatial contiguity principle). Presenting words and pictures simultaneously may be fruitless if the portions are far apart in the visual field.

Lastly, the signaling principle is also intended to reduce extraneous processing by signaling, cuing or emphasising key information (Mariano et al., 2009; Mautone & Mayer, 2001). Thus, the goal is to prevent extraneous cognitive overload by providing cues (e.g., highlighting, outlining or intoning), guiding the learner towards essential material (Lorch, 1989; Mayer, 2005b). The principle is especially applicable when the learning material is unavoidable extraneous and complex (Mayer, 2011a).

These are only a mere handful of the multimedia design principles that Mayer and his colleagues have explored. Since the motive behind CTML is to develop rewarding instructional design, both grounded in cognitive theory and supported by empirical data, these principles may merge or otherwise evolve as the research progresses. A main aspect of de Jong's (2010) criticism stems from Mayer's introduction of *boundary conditions*, or, the circumstances where the principles are ineffective or may have a reversal effect (i.e., cause less learning). Most of the principles within CTML tend to have best effect on low-knowledge leaners (e.g., novice students) rather than high-knowledge leaners (e.g., advanced students), and when the material is system-controlled, complex and fast-paced (Mayer, 2009, p. 266). The *expertise reversal effect* is a result of conditions where the principles fail to foster learning. For instance, worked-out examples and direct instruction may be fruitful for low-knowledge learners, but a hindrance for high-knowledge leaners, who according to Kalyuga (2009, p. 76) would benefit more from problem-solving practice and guided exploratory environments. In his retort to de Jong, Mayer (2010b, p. 144) states that the boundary conditions benefits CTML by verifying "the predictions of the theory, to sharpen the theory, and to better present practical implications". The principles are not meant as absolute instructions applicable for all imaginable scenarios, and should be used in accordance with the underlying theory. Furthermore, the focus on controlled experimental research have led to questions whether the results are valid in realistic and immersive learning environments (Lohr & Gall, 2004; Torgersen, 2012). Mayer (2011b) acknowledges this concern and advice that future research should particularly be conducted in authentic learning environments and concentrate on defining the boundary conditions of current and future multimedia design principles.

Mayer (2009, p. 231) claims questions regarding which instructional medium is best are unproductive, but the question raised in this study is not whether PowerPoint is objectively better than a blackboard, but rather what attitudes students' have and how they perceive the usage of these mediums. If one accepts Mayer's argument concerning generative processing and Wittrocks's theory of generative learning, it would be appropriate to assert that students' attitude toward instruction mediums have some influence in their ability to foster meaningful learning. The following chapters intend to shed some light on these attitudes based on the opinions of a medium-sized sample of Norwegian students.

3. Methodology

The thesis is based on a quantitative research design, and the upcoming chapter aims to outline the systematic approach behind the study. The first section presents an overview of the participants in the study, whereas the main bulk aims to describe each step of the process, from the preparation of the questionnaire, to the implementation of the data acquisition and the subsequent assessment of data quality and data analysis. In the concluding segments some ethical considerations will be discussed.

3.1. Participants and Design

The targeted population for this study were active students attending either the university or a university college in Bergen, preferably within a variety of study programs and curriculums. It was carried out using a cross-sectional design within a non-experimental descriptive and exploratory survey research. Both design and research format are among the most common types of quantitative inquires in education (Lodico, Spaulding, & Voegtle, 2010, p. 223). Louis Cohen, Lawrence Manion and Keith Morrison (2011, p. 257) claim, “[s]urveys are useful for gathering factual information, data on attitudes and preferences, beliefs and predictions, opinions, behaviour and experiences – both past and present”, and the purpose of the inquiry was to provide an overview of students’ attitude toward multimodal presentations and traditional lectures. The study used a convenience sampling, where lecturers were contacted through the supervisor, reducing the possibility of pursuing generalization for a wider population (L. Cohen et al., 2011, p. 155).

An accumulated sample was acquired from four separate sessions and included students from four study programmes (N = 174), with 94.8% (n = 165) completing the survey. The operational dataset was comprised by 66.7% (n = 110) females, 32.5% (n = 54) males, with one student abstinent. In which 22 attended an introductory course in psychology, 27 were third year dentistry students, 56 attended a one-year program in education and 60 were medicine graduates. With one student abstaining, 44.8% (n = 74) reported they were 19-24 years of age, while 47.9% (n = 79) responded they were 25-29 years. The remaining 6.6% (n = 11), being 30 years or older, were merged into the latter group. When asked about their grade average from upper secondary education, 14.5% (n = 24) specified they had D or better, but less than C, 26.7% (n = 44) reported they had C or better, but less than B, while 54.5% (n = 90) said they had B or better, but less than A. With one student abstaining and therefore excluded, the remaining 3.6% (n = 6), having a straight-A average, were merged into the latter group. The students were also asked how many credits they had amassed from higher education, with alternatives ranging from 0 credits to 300 and more. The original seven groups were reconstructed, resulting in three final categories, 0-59 (24.8%, *n* = 41), 60-299 (29.1%, *n = 48*) and 300 credits or more (44.8%, *n = 74*), with two students abstaining (see Table 2).

Table 1
Participant Demographics

Item	Type	Total		Psychology		Dentistry		Education		Medicine	
		n	%	*n*	%	*n*	%	*n*	%	*n*	%
Gender											
	Female	110	66.7	14	63.6	21	77.8	39	69.6	36	60.0
	Male	54	32.7	8	36.4	6	22.2	16	28.6	24	40.0
	Missing	1	0.6	-	-	-	-	1	1.8	-	-
	Total	165	100	22	100	27	100	56	100	60	100
Age											
	19-24	74	44.8	15	68.2	12	44.4	46	82.1	1	1.7
	25-29	79	47.9	4	18.2	13	48.1	6	10.7	56	93.3
	30-32	3	1.8	-	-	1	3.7	-	-	2	3.3
	≥33	8	4.8	4	13.6	1	3.7	4	7.1	-	-
	Missing	1	0.6	-	-	-	-	-	-	1	1.7
	Total	165	100	22	100	27	100	56	100	60	100
Gender in Age Groups	F: 19-23	54	32.7	11	50.0	10	37.0	32	57.1	1	1.7
	F: ≥25	55	33.3	3	13.6	11	40.7	7	12.5	34	56.7
	M: 19-24	19	11.5	4	18.2	2	7.4	13	23.2	-	-
	M: ≥25	35	21.2	4	18.2	4	14.8	3	5.4	24	40.0
	Missing	2	1.2	-	-	-	-	1	1.8	1	1.7
	Total	165	100	22	100	27	100	56	100	60	100
Grade Average From Upper Secondary School	≥D<C	24	14.5	1	4.5	-	-	23	41.4	-	-
	≥C<B	44	26.7	13	59.1	3	11.1	27	48.2	1	1.7
	≥B<A	90	54.5	7	31.8	23	85.2	6	10.7	54	90.0
	A	6	3.6	-	-	1	3.7	-	-	5	8.3
	Missing	1	0.6	1	4.5	-	-	-	-	-	-
	Total	165	100	22	100	27	100	56	100	60	100
Credits From Higher Education	0	30	18.2	1	4.5	-	-	29	51.8	-	-
	1-59	11	6.6	-	-	-	-	11	19.6	-	-
	60-119	20	12.1	14	63.6	-	-	6	10.7	-	-
	120-179	2	1.2	1	4.5	-	-	1	1.8	-	-
	180-239	11	6.7	2	9.1	4	14.8	5	8.9	-	-
	240-299	15	9.1	2	9.1	12	44.4	1	1.8	-	-
	≥300	74	44.8	2	9.1	11	40.7	1	1.8	60	100
	Missing	2	1.2	-	-	-	-	2	3.6	-	-
	Total	165	100	22	100	27	100	56	100	60	100

3.2. Materials and Apparatus

The chief instrument for the study was a questionnaire developed by the researcher in collaboration with his supervisor. During the planning phase, in late spring 2012, it was decided to use a digital personal response system (clickers) as a mean for collecting data. This section aims to describe the specifics regarding these crucial elements of the study.

3.2.1. Questionnaire. The development of the questionnaire started in April 2012, with the early draft strongly influenced by Krumsvik, Kristine Ludvigsen and Helga B. Urke (2011) and Susskind (2005, 2008). The former study, though intended for pupils and teachers at upper secondary education, set the basis for the demographic and media literacy items for this current research. Susskind's studies were essential in constructing the items concerning attitudes toward multimodal presentations and traditional lectures. The first draft, accompanying a project plan, was submitted to the Faculty of Education in May 2012, in conformity with the requirements needed to initiate the project (see Appendix B-1 for access to each version of the questionnaire).

During August, the following term, the questionnaire went through its first revision. Since the draft had a traditional paper-survey design, the first step was to create a PowerPoint document with a separate slide for each item. The presentation was shaped to be simple, following Mayer's guidelines with any redundant details (graphics) removed and essential cues highlighted (underlined). Based on feedback from the supervisor it was clear there were too many items in the survey. Choosing clickers as part of the apparatus entailed certain restraints on the research design, the foremost being the timeframe. Initially each session had a fifteen minute schedule, and depending on the sample size, thirty-five items would approximately be within the limits. The first draft had fifty items. It was therefore decided that three items (13 - 15) from Susskind's (2005) original scale concerning preparation for exams, a subscale from Krumsvik et al. (2011) study measuring media literacy, in addition to items regarding students' non-academic use of digital equipment during lectures were removed. The revised questionnaire encompassed twenty-eight items.

The second revision had emphasis on defining items more precisely and the largest transformation was the scale used for measuring students' attitude toward multimodal and traditional lectures. Susskind (2005) used a 7-point scale, with one indicating a strong preference for multimodal presentations (i.e., PowerPoint) and seven indicating a strong preference for traditional lectures. Granted, this might suit Susskind's study and quasi-experimental design, it was not deemed adequate for this project. The rationale behind this decision was while a student might prefer multimodal presentations over traditional lectures when confronted with the aforementioned scale, he or she might as easily (dis)approve of them both to some degree. The original thirteen items was consequently split in two, with thirteen statements measuring attitudes toward multimodal presentations, and thirteen mirroring statements measuring attitude toward traditional lectures. The scale itself was changed to a 7-point Likert-type scale: 1 = completely agree; 2 = strongly agree; 3 = agree; 4 = neither or; 5 = disagree; 6 = strongly disagree; and 7 = completely disagree. Due to this change the second revision included forty-six items.

A third revision was done before conducting a pilot study. The goal was to remove excess items that did not fit with the design, and further clarify questions, statements and answers. The first change was to remove additional items from Susskind's (2005) study, these were item 9 – 12 on the original scale and resulted in the removal of eight items all involving note taking. Some changes were also made for the demographic section of the questionnaire, where an item concerning grade average from studies in higher education was changed to require grade average from upper secondary education. Two items meant to acquire information about academic progress were reviewed, one item was removed and the other enlarged to include more credits earned. The third revision encompassed thirty-seven items and a small-scale pilot study was conducted to examine if the items were well defined and easily understood. David Clark-Carter (2010, p. 85) states that a pilot study is particularly important when using measures devised by the researcher, and feedback was a necessity for further development since the survey instrument was mostly rebuilt from the ground up.

The pilot was conducted on September 6th within a closed Facebook group retained for fellow M.Ed.-students (N = 19). The researcher made a post containing a link to a web based survey, and within eight hours it had been viewed by all members. The survey was available for twenty-four hours with 42% (n = 8) of the students responding, whilst others gave both written and oral feedback. The survey was presented in such a way that it could be easily understood, with a very basic design and without any graphics. The first eight items (question 1 – 8) were designed to obtain individuals' demographics information. Secondly 11 times (question 9 – 19) were meant to gather information about students' perception of their own, and their lecturers, media literacy, and additionally gather information regarding the students routines for note taking (if they used digital equipment or pen and paper) and their lecturers' use of multimodal presentations software. Lastly came 18 items (20 – 37) tied to students' attitude toward multimodal presentations and traditional lectures.

As the pilot had only eight respondents the most valuable information was collected through the feedback given. After several comments on the Likert-type scale, *(dis)agree* was altered to *slightly (dis)agree*, based on the reasoning that the former sounded finite. Still, some information was gathered through the numerical data. Item four, originally phrased "how many credits do you have from your current study" was changed to "[…] from higher education". The researcher had anticipated the M.Ed.-students would answer the same, but it was clear the question was interpreted differently among the students. Some counted only masters, which would be 60-119 credits at the time, while others counted both bachelors and masters resulting in 240-299 credits. After consulting with the supervisor it was agreed to remove all items relating note taking. Furthermore, it was decided to use Mayer's (2009) Cognitive Theory of Multimedia Learning (CTML) as a theoretical framework, thus making it easier to ground the empirical data.

Therefore, items 15 through 20 in the final version encompassed principles connected to CTML. Additionally, one item (11) was added with the purpose to obtain whether or not the students' believed their lecturers to be aware of current didactical research; a second item (12) was added to gather information on students' preferred lecture format; a third item (13) was added for collecting data on students' perception of the intent behind their lecturers' use of multimodal presentation; and lastly, two items (15 – 16) was added to gather information on lecturers' use, and students' perceived learning outcome from multimodal presentations. These items were acquired from Krumsvik and Ludvigsen (2012). From the 18 items linked with attitudes toward multimodal presentations (AtMP) and traditional lectures (AtTL), only *structure* (items 24 – 25), *learning outcome* (26 – 27), *motivation* (28 – 29) and *interaction* (30 – 31) were retained as these were deemed adequate for a theoretical construct.

The final version of the questionnaire contained 31 items and was completed on September 10th. The first data session was scheduled the following day and consequently it was not feasible to carry out a full scale pilot. Hence, due to the changes between the third revision and final version this study may be considered a pilot.

3.2.2. Personal response system. One concern prior to the study was linked with response, or more precisely, lack thereof. Clark-Carter (2010, p. 74) points out that the non-respondents may share attributes that undermines the basis for sampling, and consequently lead to biased results. According to Lodico et al. (2010, p. 221), the non-respondent is often found among those without any real sentiments toward the nature of the inquiry, and consequently do not feel encouraged to fill out or return the survey. As such, if the respondents are merely those with strong opinions, either for or against the subject, the results might not reflect the true population. Hence, Lodico et al. emphasises that research aiming for publication should have a response rate at least 50%, and preferably higher than 70%. L. Cohen et al. (2011, p. 261) note that online surveys tend to have less item non-response (missing data) than paper-based surveys, nevertheless, there may be more non-respondents as a whole. Furthermore, Lodico et al. (2010) claim that online surveys are among the poorest concerning response rate.

The researcher was therefore reluctant to use this method. Lastly there was a choice between using a traditional paper-survey or to use clickers. The Digital Learning Communities (DLC), a research group associated with the Department of Education and led by Krumsvik, had for other purposes invested in both a potent laptop running a Windows operative system and the TurningPoint (2012) personal response system. TurningPoint is a polling software that embeds itself in Microsoft PowerPoint and is used in much the same fashion as an ordinary presentation. The difference rests in the radio frequency response transmitters and a radio frequency receiver connected to a computer running PowerPoint and TurningPoint. The transmitter comes in different shapes, but most resembles a small remote control (hence, *clicker*). The transmitters are uniquely coded so that the TurningPoint software recognises each different transmitter and indices the answers accordingly. One might display the PowerPoint slides, containing statements or questions with appurtenant answers on a computer screen, a TV or through a projector, whilst the respondents use their clickers to deliver their responses.

The decision to use clickers had both a pragmatic, philosophical and personal rationale. The latter, and the one with least weight, was the researchers' childlike fascination for gadgets. More sincere was the philosophical assumption that a study of multimodal presentations would benefit from using a multimodal approach. Still, the most important aspect was response-rate, efficiency and practicality. The redeeming features of a paper-survey was that it could be delivered, filled out and returned swiftly, with each respondent having time to read through and contemplate their answers individually. It also entailed the possibility of developing more complex and comprehensive questionnaires. The use of clickers on the other hand would require a more disciplined construction and narrow focus. A session using clickers would demand a larger timetable, putting more strain on the respondents and reducing the available time for lecturing. It would also require the respondents to wait until everyone had answered each item. There was also an uncertainty whether the approach would produce a higher item non-response rate relative to a paper survey. Despite the drawbacks using clickers, the researcher believed that both students and lectures would find this alternative to be more appealing, preferably resulting in a higher response rate. An additional argument for using clickers is the ease in which the raw data is compiled in a Microsoft Excel file and then transferred to the analysing software. With a paper-survey the researcher would enter all the data manually, not only tedious and time consuming, it would also add an error source.

One might argue that a paper-survey is much cheaper than investing in clickers, and though true, the DLC already had, therefore printing out sheets of papers would not only be more costly, it would also be bad for the environment. Thus, the choice fell on a personal response system and TurningPoint.

3.3. Procedure

The results presented in this study are based on student responses from four independent data acquisitions, each conducted through direct administration by the researcher and supervisor using the same materials and apparatus. A prerequisite for the survey was a mean of displaying the PowerPoint slides, and fortunately a projector was available for all sessions. The data was collected on four different locations in the period between September 11th and November 9th 2012, with each session having a length of 17 – 27 minutes. Regarding the sample, two of the original 174 students left before a session, while four arrived after a session had started. In addition, during the final session a rouge partial response were registered, believed to be caused by an excess, stray clicker and an overzealous student (see Table 2 for details).

An important aspect of the procedure entailed keeping the sessions as identical as possible, ensuring all participants received the same information. Each session started with the researcher and the supervisor counting the attending. The researcher then handed out the clickers, whilst the supervisor explained their function. When all participants had received a clicker, the researcher introduced himself and stated the purpose for the study. He made sure to point out that participation was completely voluntary at all stages and that the participants were ensured anonymity. It was emphasised when a button was pressed, the decision would be final, and consequently all should contemplate their answer thoroughly. The participators were also encouraged to raise any questions when encountered.

The researcher and supervisor agreed it would be redundant to read out the questions, statements and answers aloud, as this could possibly lead to a discrepancy between the oral and written information (cf., Kalyuga, 2012, p. 156). The participators determined the pace, and the teacher supervisor only intervened if one or two failed to answer within a reasonable time. He would then advice everyone to make certain they had provided an answer, and regardless the survey would move on to the next item within 10 seconds. After the initial items on individual demographics were completed, the supervisor read out and described how multimodal presentations, traditional lectures, media literacy and plenary lectures were defined in the study. Except for these clarifications the survey would continue without interruptions until the end of the questionnaire. At the end of the session all attending, both students and lecturer, was thanked for their cooperation.

Table 2
Procedure Details

Study Programme	*n*	Duration	Date	Notes
Psychology	24	17 min	11.09.12	1 student arrived after the session had started.
Dentistry	28	22 min	20.09.12	1 student arrived after the session had started
Education	59	25 min	21.09.12	2 students left before the session started.
Medicine	63*	27 min	09.11.12	2 students arrived after the session had started..

Note. *6 of the 31 items had 1 extra registered respondent.

3.4. Data Analysis

The data was analysed using IBM SPSS Statistic Version 21, by initially importing the raw data from Microsoft Excel. With four sessions equalling four excel files; it was believed creating a SPSS template for each session, in addition to the aggregate file, would ease the process. The template contained 31 variable names, and the data was transferred by copy and paste method from the corresponding Excel file. The data was subsequently screened for errors, but no violations were found. The preliminary analyses also included a screening for missing data. The original matrix had 169 missing entries, with an item non-response rate of 24.3% for the survey as a whole; where 75.7% completed all items, 17.2% missed one item, 3.6% missed two items, 1.8% missed three items, 0.6% missed seven items, 0.6% missed eight items and 0.6% missed 25 items. The last being the infamous stray clicker (see Appendix C-2 for an overview). No single item had less than one, or more than five missing cases, with a mean of 2.1 missing case per item and 0.4 missing entries per respondent. Though AtTL had more non-response items than AtMP there were no indications these were systematically avoided

It was decided that eligible observations had to complete at least one of the AtMP and AtTL scales, each compassing four items. More than ninety per cent of the students (93.4%, n = 155) completed both scales, whereas 4.2% (n = 7) and 1.2% (n = 3) completed AtMP (n = 162) and AtTL (n = 158) respectively. Three students did not complete any of the scales and was therefore removed from the dataset. Thus, 165 observations were deemed qualified for further analyses. The following section sets out to portray how the data were prepared and analysed, starting with the examination of validity and reliability.

3.4.1. On the relationship between validity and reliability. L. Cohen et al. (2011, p. 179) write, "reliability is a necessary but insufficient condition for validity in research; reliability is a necessary precondition of validity, and validity may be a sufficient but not necessary condition for reliability". As it seems the two concepts share a complex relationship. *Reliability* may be defined as consistency, meaning a reliable instrument is able to measure a specific phenomenon and produce similar results on repeated testing (Clark-Carter, 2010, p. 28), and *validity* refers to the degree to which the instrument measurers what it was intended to measure (Lodico et al., 2010, p. 93). To exemplify, a clock (or a similar instrument) is needed to measure intervals of time, and the most common usage is to tell the time of day. A well-functioning clock measures time precisely each day, every day. It is *reliable*. In Norway one uses the 24 hours notation as representation of time, whereas the 12 hours AM/PM system is standard in most English speaking countries. These time conventions are well-defined, albeit arbitrary concepts, which misconceived will render the interpretation of an otherwise reliable clock *invalid* (e.g., mistaking 10:30 p.m. for 10:30). The inference in this example is that the clock's reliability is adequate, but its use mistaken, hence the validity is poor even if the theoretical framework is initially sound.

Validity and reliability are measured in degrees since research cannot be 100% flawless. One of the most reliable clocks in the world, the NPL-CsF2, is only accurate to within one second over one hundred and thirty-eight thousand millennia (Ruoxin, Kurt, & Krzysztof, 2011). The uncertainties are caused by measurement errors, which can be both systematic and random. The accuracy of the NPL-CsF2 is limited by physical effects known to cause frequency shifts in the clock's operation, and are of a *systematic* nature. Such errors are consistent from one measurement to the next and can, if known, be counterbalanced (e.g., when a clock is consistently one hour late). These errors will not affect the reliability of the instrument, but if the effects are unknown it may weaken its validity. *Random* errors do influence the instruments' reliability, weakening the consistency between measurements. Daniel Muijs (2010, p. 62) claims "[t]his type of error is usually quite limited in scientific measurement instruments but can be quite substantial in educational measurement". Unpredictable errors, even those that can somewhat be counterbalanced by replicating the research on several occasions, are often caused by flaws with the instruments itself (cf., the aforementioned pilot study and item four), by environmental factors (i.e., when and where the data collection was conducted), by individual factors within the sample (i.e., physical or psychological states) or by mistakes made by the researcher (e.g., plotting or reading of the data).

For the current study it is plausible that the spacing between the three first data acquisitions in September (closer to the summer holiday) and the last in November (closer to exams) have caused an irregular fluctuation. The decision to use clickers as part of the research design is another source for measurement errors. During the last session, two students informed they voted *yes* to item nine, when they in fact meant to vote *no*, and it is highly unlikely that these were the only two instances. Another issue that might be a cause for concern is the setting in where the data was collected. Since the sessions were situated in an auditorium or classroom with all respondents present, there may have been some interactions among the students affecting the independence of observations (Pallant, 2010, p. 126). It is clear that both instrument design and research strategy will affect the reliability, and consequently the validity of a study

(Muijs, 2010). Though there are many different types of validity and reliability, only those deemed most relevant for this pilot study, namely construct validity and internal-consistency reliability are discussed here.

3.4.2. Construct validity. The attitude toward multimedia presentations and traditional lectures scales are latent variables that cannot be measured directly (Muijs, 2010, p. 57). Abraham Naftali Oppenheim (2000) claims most researchers would agree that a sound definition of attitude would be

> [...] a state of readiness, a tendency to respond in a certain manner when confronted with certain stimuli. […] Attitudes are reinforced by beliefs (the cognitive component) and often attract strong feelings (the emotional component) which may lead to particular behavioural intents (the action tendency component). (pp. 174-175)

The AtMP and AtTL scales are theoretical constructs, based on the measured degree to which the respondents' (dis)agree that lectures using multimodal presentations or traditional lectures are more *structured* (items 24 – 25), their *learning outcome* (items 26 – 27) is better, their *motivation* (items 28 – 29) to attend lectures greater and the *interaction* (items 30 – 31) between lecturer and students is heightened. One could argue, and rightfully so, that structure, motivation, interaction and learning outcome are themselves abstract constructs, latent variables, in need of their own subscales and manifest variables. At the current stage AtMP and AtTL are rather basic and narrow built constructs, and as such it is not possible to determine if for instance motivation to attend multimodal presentations or traditional lectures is commonly intrinsic, extrinsic or both in nature. Additionally, it is not implied in any way that the four items encompass all aspects of attitudes toward these lecturing mediums. Pace or note taking could possibly be connected to both AtMP and AtTL or with structure as a sub-item, whereas environmental factors, such as the design and interior of the auditorium, including the digital equipment (e.g., state of the art versus old and ragged) may affect students' attitudes. Individual qualities among the lecturers may naturally play a part as well.

If the two scales developed for this pilot study can be said to have high construct validity, there has to be a close alignment between the instrument and the theoretical construct (Clark-Carter, 2010, p. 30). L. Cohen et al. (2011, p. 189) state, when assessing construct validity one may use factor analysis, which is both a method and a common denominator for different methods of grouping together common variables based on patterns of intercorrelations (L. Cohen et al., 2011, p. 674; Tabachnick & Fidell, 2007, p. 633). Hence, an exploratory factor analysis (EFA) with principal axis factoring (PAF) was conducted to examine if the four manifest variables for each scale were unidimensional, thus referring to one construct (i.e., AtMP or AtTL). Before conducting the FA, some preliminary measures had to be taken. The items concerning learning outcome in AtMP and AtTL were initially negatively worded and were consequently recoded equalling the six other items. The 7-point Likert-type scale was also recoded resulting in: 3 = completely agree; 2 = strongly agree; 1 = slightly agree; 0 = neither or; -1 = slightly disagree; -2 = strongly disagree; and -3 = completely disagree. The compiled scales would therefore range from ±12, representing the array between negative to positive attitudes.

Barbara G. Tabachnick and Linda S. Fidell (2007, p. 614) claim a favourable factor analysis should be founded on several variables at a ≥ 0.30 correlation coefficient level, and the four items for each scale ranged from .52 to .73 (cf., Appendix C-3). Tabachnick and Fidell (2007) also note that multicollinearity and singularity is a problem when determining factor scores in FA. Consequently, four multiple regression analysis with collinearity diagnostics were performed for each scale. The squared multiple correlations (SMC) for each item were computed, in which one would equal singularity and figures close to one would equal collinearity. None of the regressions produced a SMC higher than .64, indicating that multicollinearity was not a threat in the data set (Tabachnick & Fidell, 2007, p. 657). Also, since a non-normal distribution could impair the reliability of the FA, normality was assessed using both statistical (see Appendix C-7) and graphical methods (see Appendix C-8). Normal distribution was deemed probable if skewness and kurtosis fell in the range of ±2 (Cameron, 2004, p. 544). None of the items exceeded this limit.

The reliability of PAF is also sensitive to nonlinearity among the variables, but scatterplots indicated all items shared a linear relationship. Furthermore, both univariate and multivariate outliers are prone to have more influence on the FA than other cases (Tabachnick & Fidell, 2007, p. 613). Though a calculation of z-scores (see Appendix C-7) exposed that the significance of skewness within the structure item of AtMP was 4.21, exceeding the 3.29 limit suggested by Tabachnick and Fidell (2007, p. 96), the boxplots revealed no univariate outliers. As all the other items revealed neither an outlier in the boxplots nor indicated violations of z-score, no cases were removed from the data set. Multivariate outliers were detected using multiple regressions measuring the Mahalanobis distance, defined as the distance of a particular case from the centroid of the remaining cases, and where the centroid is the point created by the means of all the variables (Tabachnick & Fidell, 2007, p. 74). The criterion for multivariate outliers is defined as the Mahalanobis distance at $p < .001$ and is evaluated as a chi-square (χ^2), with degrees of freedom equalling the number of variables (Tabachnick & Fidell, 2007, p. 99). Thus, any entries exceeding $\chi 2$ (4) = 18.47 would be considered an outlier (Tabachnick & Fidell, 2007, p. 949). The analysis showed that both AtMP ($\chi 2$ = 23.03) and AtTL ($\chi 2$ = 19.02) each had an entry surpassing the limit, Nevertheless, since the cases were unrelated and within a reasonable margin of error, the cases were not removed, and a further inspection indicated that the two multivariate outliers did not mask other outliers.

In accordance with the recommendations of Tabachnick and Fidell (2007, p. 614) the Kaiser–Meyer–Olkin measure of sampling adequacy was good (> .821), the Bartlett's Test of Sphericity was significant at $p < .001$ level and the Kaiser's measures of sampling adequacy was at an acceptable level for both scales (> .770). Consequently, support was found for the factorability of the correlation matrix of a one factor structure explaining 67.2% (Eigenvalue = 2.69) of the shared variance for AtTL and 63.4% (Eigenvalue = 2.54) for AtMP. Moreover, all factor loadings exceeded .708 on each construct, and with only one factor surpassing .48 in Eigenvalue, a Parallel Analysis was considered redundant. The residuals were computed between observed and reproduced correlations, ranging from < .001 to .017 with 0.0% non-redundant residuals and absolute values greater than 0.05, thus supporting a one factor solution. Tabachnick and Fidell (2007) state a sample size of about 150 cases should be sufficient when the FA have several high loading marker variables (> .80), as such the solution was believed sound (see Table 3).

Table 3
AtMP and AtTL Factor Matrix

Item	AtMP [a]	AtTL [b]
Structure	.889	.796
Motivation	.754	.895
Interaction	.823	.800
Learning Outcome	.708	.783

Note. [a] *n = 162.* [b] *n* = 158

3.4.3. Internal-consistency reliability. The previous section tried to establish if the items constituting the AtMP and AtTL were measuring the same latent construct accurately, thus invoking high construct validity. A necessary precondition for validity is reliability and in cross-sectional quantitative research the most common procedure for measuring this attribute is through internal consistency analysis, and more specifically through Cronbach's coefficient alpha (Field, 2009, p. 674). Neil Schmitt (1996, p. 350) states, "[i]nternal consistency refers to the interrelatedness of a set of items, whereas homogeneity refers to the unidimensionality of the set of items. Internal consistency is certainly necessary for homogeneity, but it is not sufficient". The implication being that the Cronbach's alpha (short, alpha or α) may indicate high inter-item correlations (i.e., good internal consistency) even if the items themselves measures different constructs. Still, alpha can be used together with a factor analysis to assess if the items are actually unidimensional (Tavakol & Dennick, 2011, p. 54). Alpha is a split-half reliability test, meaning the scale is divided into all possible halves, wherein a correlation coefficient is calculated for each combination (Clark-Carter, 2010, p. 311). With four items there are three possible ways one could divide AtMP/AtTL into two halves. Alpha is measured in then range between < 0 and 1, with higher values signifying greater reliability, and can be calculated with the formula below,

$$alpha = \frac{nr_{ij}}{1 + (\mathrm{n} + 1)r_{ij}}$$

Equation 1 *Cronbach's alpha*

where r_{ij} is the mean of all the inter-item correlations and n is the number of items in the scale (L. Cohen et al., 2011, p. 640). Julie Pallant (2010, p. 97) points out that alpha is sensitive to the number of items in the scale, and that a presentation of r_{ij} may be more suitable if there are fewer than ten items. Pallant refers to Stephen R. Brig and Jonathan M. Cheek (1986, p. 114) recommending an optimal range for the inter-item correlation of .2 to .4. Whereas Lee Anna Clark and David Watson (1995, p. 316) suggest a higher mean, possible in a .4 to .5 range, when measuring a narrow construct. It is quite obvious that low intercorrelations may indicate the items are measuring different constructs, but Clark and Watson also informs that high internal consistency could threaten the construct validity through what they call *the attenuation paradox*. The paradox can briefly be described as a result of items having strong intercorrelations, but where some of the items don't contribute with unique or incremental information, thus being redundant. It should therefore be noted that with r_{ij} calculated at .63 (AtMP) and .67 (AtTL), the construct validity of the instrument may be compromised due to narrowness of the scales (see Table 4).

Table 4
AtMP and AtTL Cronbach's Alpha Coefficient of Internal Consistency

	AtMP[a]			AtTL[b]		
Institution	*N*	r_{ij}	*A*	*N*	r_{ij}	*α*
Psychology	22	.47	.78	19	.31	.65
Dentistry	27	.68	.90	27	.57	.84
Education	55	.44	.76	54	.51	.81
Medicine	58	.45	.77	58	.49	.79
Total	162	.63	.88	158	.67	.89

Note. a) Consists of items 24, 26, 28 and 30. b) Consists of items 25, 27, 29 and 31.

There is also a longstanding debate concerning the acceptable levels of alpha. Clark-Carter (2010) claims the .7 level is the most quoted modicum, while others (e.g., L. Clark & Watson, 1995; L. Cohen et al., 2011; Schmitt, 1996) note the minimum criteria often ranges from .6 and up to .9 alpha coefficient. According to guidelines in Table 5, as proposed by L. Cohen et al. (2011), in addition to the EFA conducted in the previous section, one may assert that the AtMP (α = .88) and AtTL (α = .89) are both unidimensional and acceptable reliable.

Table 5
Cohen, Manion and Morrison Alpha Coefficient Guidelines

α	Rating
> .90	Very highly reliable
.80 – .90	Highly reliable
.70 – .79	Reliable
.60 – .69	Marginally / minimally reliable
< .60	Unacceptably low reliability

3.4.4. Descriptive and inferential statistics. The overarching objective for this study was to examine students' attitude toward multimodal presentations and traditional lectures, and secondly assess students' perception of the multimedia, modality, temporal contiguity and signaling principles within Mayer's (2009) Cognitive Theory of Multimedia Learning (CTML). To guide this enquiry seven research questions (RQ) were postulated, in which the first four questions were linked with AtMP and AtTL, and the last three with CTML (see Table 6 for an overview). This section aims to depict the variables and statistics used to answer these questions.

3.4.4.1. Analysing techniques. The study applied both descriptive and inferential analysing techniques. Descriptive techniques includes methods for summarizing and presenting data, thereof describing the composition of categorical data (e.g., age and gender distributions) or the enumeration of continuous variables (e.g., means and standard deviations). Inferential techniques encompass different methods of analysing data where the aim is to make inferences or predictions for the populations based on the current sample (L. Cohen et al., 2011). Three main inferential approaches were carried out at α = .05 level of significance, including two-tailed correlation (Pearson's correlation), one-way analysis of variance (ANOVA) and regression (multiple, hierarchically and binary logistic). The level of significance was chosen to balance the probability of making a type I error, against the risk of making a type II error. Where the first is not finding support for a null hypothesis (H_0) that is true, and the latter is finding support for a H_0 that is false (Lodico et al., 2010, p. 301). The alpha was also chosen on grounds of conventional practice found in educational research, though the level is mostly historical and somewhat arbitrary (Field, 2009, p. 51).

The Pearson product-moment correlation coefficient measures the degree of a linear relationship between two continuous and normally distributed variables. The Pearson's correlation, denoted by *r*, ranges from ±1, where *r* indicates the extent to which the pattern of paired points represents a straight line. A positive correlation indicates that an increase in variable A equals an increase in variable B, whereas a negative correlation entails that an increase in variable A equals a decrease in variable B (or vice versa). A zero correlation, $r = 0$, indicates there is no relationship or covariance between the variables (Clark-Carter, 2010, p. 286). The study used a two-tailed (non-directional) approach, which unlike the one-tailed (directional) test makes no presumptions regarding the nature of a possible relationship (i.e., positive/negative correlation). Thus, when the alpha-level is .05, the probability of significant results is split in two equal proportions of 0.25 on each side of the distribution, making the two-tailed test a more conservative method (Clark-Carter, 2010, p. 168). The equation for Pearson's correlation is,

$$r = \frac{cov_{xy}}{s_x s_y} = \frac{\sum_{i=i}^{n}(x_i - \overline{x})(y_i - \overline{y})}{(n-1)\left(\sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \overline{x})^2}\right)\left(\sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \overline{y})^2}\right)}$$

Equation 2 *Pearson product-moment correlation coefficient*

where x_i and y_i are the two variables in question, and $\overline{x}$ and $\overline{y}$ are the means of the variables set in an iterative (summation) process and subsequently divided by the degrees of freedom (n – 1). This is a cross-product deviation known as covariance, and though a good way to assess a relationship, it is dependent on the scales used (Field, 2009, p. 169). The Pearson correlation coefficient is a form of standardization where both scales are converted into a standard set of units. This is accomplished by dividing the covariance by the standard deviations of the two variables ($s_x s_y$). The equation may look fairly complex, but is in fact a rather simple, albeit tedious procedure, and with a relatively large sample size it is best that SPSS will handle the calculations (Field, 2009). For research question five there will also be used an alternative analysis called biserial correlation (Field, 2009, p. 184). The biserial equation is based on point-biserial correlation, which is a Pearson's correlation between a continuous variable and a discrete dichotomy (e.g., gender), and is used since one of the variables is a continuous dichotomy (e.g., a collapsed continuous variable).

The effect size of r can be measured at ±.01 indicating a small effect, ±.3 a medium effect and ±.5 a large effect size (J. Cohen, 1992, p. 157). The Pearson's r is not measured on a linear scale, meaning the effect of .05 is not five times as great as .01, but it is still useful as an objective measure of the effects importance (Field, 2009, p. 57). To better explain the relationship between the two variables one can square r, resulting in what is known as the coefficient of determination, denoted by R^2. Though R^2 cannot be used as a proof of causality (e.g., that variance in variable A causes changes in variable B), it can measure the amount of variability in one variable that is shared by the other. If the Pearson's correlation is calculated at ±.05, implying a large effect size, then R^2 would equal 0.25 or 25% of shared variation between the two variables (Field, 2009, p. 179). Thus, effect sizes are a gauge of the strength of a relationship between two variables (J. Cohen, Cohen, West, & Alken, 2003)

Lastly, there is the issue of statistical significance, denoted by *p*, which could be explained as the probability of the results being different from the null hypothesis (e.g., that there is no relationship between variable A and B). When $p \leq \alpha$ and $\alpha = 0.5$, the empirical data has not confirmed a relationship between the two variables, it is merely a probability calculus stating that there is a 5% (or less) likelihood of the observed results occurring if the null hypothesis is true. Thus, when there is little support for a null hypothesis ($p \leq \alpha$), one could claim there is a statistically significant relationship between the two variables (Field, 2005a; 2009, p. 53). However, it should be noted that the term significant differ from a colloquial equivalent of importance, meaning that statistical significance does not necessarily imply that the results are statistically important. Field (2009, p. 171) states t-statistics (Student's t-distribution) is a common method for testing whether the correlation coefficient is different from null, and can be done using the following equation.

$$t_r = \frac{r\sqrt{\mathrm{N} - 2}}{\sqrt{1 - r^2}}$$

Equation 3 *Student's t-distribution*

L. Cohen et al. (2011) note that the level of statistical significance varies according to sample size. Providing a basis for the argument that a minuscular difference in means will be deemed statistical significant if the sample size is large enough, and consequently that a *true* null hypothesis within social science is implausible (Field, 2005a). For the current sample ($n = 162$), with a two-tailed probability of *r*, done at a significance level of .05, the critical *t*-value is ±1.9749. Indicating that $r \geq .154261$ (or 2.3% total variance) would be considered statistical significant (Chang, n.d.). As a result, Muijs (2010, p. 70) advocate the use of effect sizes in in addition to significance both on both theoretically and pragmatically grounds.

The one-way ANOVA is a technique that compares the mean of a continuous criterion variable between a categorical predictor variable with more than two groups, and examines whether the groups within the predictor variable differ significantly from each other (L. Cohen et al., 2011, p. 646). It achieves this through calculating an F-ratio, denoted by *F*, which is the ratio of *between-groups variance* divided by *within-groups variance*. If there is no significant difference between the groups means then *F* would approximate one, whereas an *F* larger than one indicates between-group variation (Clark-Carter, 2010, p. 223). A high F-ratio signifies that the groups are different, but a *post hoc* test is needed to tell which of the groups differ from each other. This procedure involves pairwise comparisons on all the different combinations of the groups within the predictor variable (Field, 2009, p. 372). The study used the Bonferroni correction and the Games–Howell procedure for *post hoc* analysis. The former controls the type I error rate well and, though a conservative method, is advantageous when relatively small numbers of comparisons are made. The latter was used in accordance with Field's (2009, p. 375) recommendations of "running the Games–Howell procedure in addition to any other tests you might select because of the uncertainty of knowing whether the population variances are equivalent". The more robust Welch's *F-ratio* was used where the assumption of homogeneity of variance had been violated (Field, 2005b; 2009, p. 380). The effect sizes are measured by omega squared, denoted by ω^2, and are weighted at .01, .06 and .14 representing small, medium and large effects respectively (Field, 2009, p. 90). It can be calculated,

$$\omega_2 = \frac{\mathrm{SS_M} - (df_\mathrm{M})\mathrm{MS_R}}{\mathrm{SS_T} + \mathrm{MS_R}}$$

Equation 4 *Omega squared*

in which $\mathrm{SS_M}$ is the between-group effect, $\mathrm{SS_T}$ is the total variance in the data and the mean square of residuals ($\mathrm{MS_R}$) measures the average amount of unsystematic variation. Df_M is the degrees of freedom for the between-groups effect.

Regression analyses, including linear, hierarchical and logistic regression, are a set of statistical techniques for which one can measure the relationship between a criterion and (several) predictor variables. (Tabachnick & Fidell, 2007, p. 117). Regression can be seen as an extension of correlations analysis, and alike to correlation studies it cannot be used as sole evidence that the predictor variables are *causing* the variance in the criterion variable (Tabachnick & Fidell, 2007). The main difference between linear and logistic regression is the nature of the criterion variable and the stringency of assumptions. Where the linear regression model assumes that the criterion variable is continuous, based on a linear relationship with its predictor; binary logistic regression use a dichotomous criterion variable (i.e., it can only be one or zero), which in its binomial nature violates linearity and normal distribution assumptions found in linear regression (Field, 2009, p. 267). Hierarchical (also called sequential) regression is a variant of standard multiple regression where the predictor variables are entered as blocks in the regression model according to the researcher specifications. Thus, one can assess what the predictors in each sequence adds to the equation when the other blocks are controlled for (Tabachnick & Fidell, 2007, p. 138). The predictors can be a combination of continuous, dichotomous or indicator-coded (dummy) variables, and is used to test the predictive power and to assess the relative contribution of each predictor. The equation for an additive multiple regressions is as follows,

$$Y_i' = \varepsilon_i + B_0 + \sum_{i=1}^{k}(B_i X_i)$$

Equation 5
Multiple regression

where Y_i' is the predicted value of the criterion variable, X_i are the predictor variables and B_i, known as unstandardized regression coefficients, are the values that Y_i' will change by if X_i changes by one unit and with all other variables being equal. The error rate, denoted by ε, measures the difference between the predicted and observed value of Y_i whilst B_0 is the value of Y_i' when X_i is zero (Field, 2009, p. 210). Tabachnick and Fidell (2007, p. 123) suggest that a minimum sample size should be the largest of $N \geq 50 + 8k$ for testing the multiple correlation and $N \geq 104 + k$ for testing the individual predictors, with k being the number of predictors. Since the regressions in the study will use 11 predictors and the sample size is $N > (50 + (8\times11)) = 138$, the minimum requirement is fulfilled according to these recommendations.

The main purpose of multiple regression is to calculate each of the regression coefficients and thereby "accomplish two intuitively appealing and highly desirable goals: they minimize (the sum of the squared) deviations between predicted and obtained *Y* values and they optimize the correlation between the predicted and obtained values for the data set" (Tabachnick & Fidell, 2007, p. 118). In addition to measure the unique contribution of each predictor on the criterion variable, it is also worthwhile to evaluate the model as a whole. This can be done by calculating the multiple correlation coefficients, denoted by R^2, which is the Pearson correlation between observed values of the criterion and the values predicted by the regression model, and therefore the amount of variation in the criterion variable that is accounted for by the predictors (Tabachnick & Fidell, 2007). The significance of the model can be tested using an *F*-ratio similar to ANOVA (Field, 2009, p. 235).

Logistic and linear regression share many similar traits, but where the former predicts the *value* of the criterion variable from the predictor variables, the latter predicts the *probability* of the criterion variable being one or zero (e.g., yes or no) from the values of the predictors (Field, 2009). Logistic regression can be seen as an extension of regression and the equation below bears many similarities with the equation for multiple regressions.

$$\hat{p}_i = \frac{1}{1 + e^{-\mathrm{B}_0 + \sum_{i=1}^{k}(B_i X_i)}}$$

Equation 6 *Binary logistic regression*

The equation is a logit (logarithmic) transformation of a multiple linear regression, where e (~ 2.7183) is the base of natural logarithms and $\hat{p}_i$ the probability of the criterion being one or zero (Field, 2009, p. 267). The other parameters are equivalents to those of Equation 5, and the objective for logistic regression is for the most part the same as for ordinary regression; which includes an assessment of the regression model and the computation of the coefficient of each predictor.

The model is assessed on grounds similar to that of ordinary regression, with a comparison between the observed and the predicted values of the criterion. Though the observed value of Y can only be one or zero, the predicted logit value will lie somewhere between these dichotomies. The measure used to evaluate the fit of the model (goodness-of-fit) is called *log-likelihood*, and is an analogue to the residual sum of squares in multiple regression (Tabachnick & Fidell, 2007, p. 446). Consequently large values in log-likelihood indicates that there are large amounts of unexplained variance in the model (i.e. poor fit, cf., Field, 2009, p. 267). Scott Menard (2002, p. 21) states that the difference between two log-likelihoods multiplied by -2 is an equivalent of a chi-square distribution if they come from two different models nested within the same overarching model. Logistic regression, like ordinary regression, uses the intercept in a baseline model to predict Y_i when X_i equals zero. Linear regression uses the mean of the criterion as a preliminary estimation, whereas logistic use the category (one or zero) with the highest frequency (Menard, 2002). If the predictors are able to predict the outcome of Y_i better than the intercept, the value of log-likelihood will be reduced, and by computing the values of the two chi-square distribution one may assess if the difference is significant. Additionally, there is the possibility of computing several varieties of a pseudo-R^2, which conceptually serves as an analogue to R^2 from multiple regression. The adequacy of the different pseudo-R^2 is a subject of controversy, and as a consequence this study will report both Hosmer and Lemeshow's (R^2_L), Cox and Snell's (R^2_{CS}) and Nagelkerke's (R^2_N) as approximations of R^2 (Field, 2009; Menard, 2002;

Tashakkori & Creswell, 2007). Research question seven had a multivariate and a direct approach, which entailed that all the predictors were entered in the equation as one block (similar to standard multiple linear regression). The computation of univariate and multivariate regression are slightly different, but conceptually they are the same.

The main assumption in logistic regression is that there is a linear relationship between the predictors (X) and the logit transformation of the criterion variable ($\hat{p}$), but the assessment of coefficients is complicated by the fact that it is not possible (or interesting) to directly calculate the means and standard deviation of a dichotomous Y (Menard, 2002, p. 52; Tabachnick & Fidell, 2007, p. 443). Instead one uses a *maximum-likelihood estimation*, which is an "iterative procedure that starts with arbitrary values of coefficients for the set of predictors and determines the direction and size of change in the coefficients that will maximize the likelihood of obtaining the observed frequencies" (Tabachnick & Fidell, 2007, p. 439). The calculations for this procedure is beyond the scope of this thesis (for an interesting look at parameter estimations of logistic regression models see Czepiel, 2002). However, when SSPS have calculated the best fitting coefficients, one may also calculate the exponentiated B (e^B), commonly known as odds ratio, which is similar to the B coefficient, but easier to interpret since there is no need for a logarithmic transformation (Field, 2009, p. 270). The e^B reflects the outcome odds of the criterion variable, meaning that an e^B greater than one indicates that a one-unit increase in the predictor variable will increase the odds of the criterion being true, and likewise if e^B is below one that the criterion will be false (Tabachnick & Fidell, 2007, p. 462). Comparable to linear regression where one uses t-statistics to assess the statistical significance of each coefficient, one may use Wald statistic in logistic regression, but the drawback is that a large coefficient will inflate the estimated standard error, causing type II error (Menard, 2002, p. 43). Jacob Cohen, Patricia Cohen, Stephen G. West and Leona S. Aiken (2003, p. 507) write that a technique named *likelihood-ratio test* is the preferred method for testing the significance of each predictor, which can be calculated as the log-likelihood of the full model less the sum of the model without the variable being tested.

3.4.4.2. Some notes on variables and analysing procedures. Despite a considerable debate surrounding the treatment of ordinal data as interval data (Jacoby & Matell, 1971; Jamieson, 2004; Lubke & Muthén, 2004) for all intents and purposes the Likert scales in this study are treated like an approximate for ratio-level measurement.

Furthermore, the terms independent and dependent variables are, according to Clark-Carter (2010, p. 314) and Field (2009, p. 7) closely tied to experimental research, consequently are the non-experimental equivalents, predictor and criterion variables used here. The focus of interest for the study was whether variations in the criterion variables could be explained by covariance with one or more of the predictor variables (L. Cohen et al., 2011, p. 607).

Among the inferential techniques used in this study, multiple regression had the most stringent terms regarding the assumptions of predictors and criterions and consequently all variables were screened according to these standards prior to conducting the various analyses (Field, 2009, p. 220). For logistic regression the continuous variables of RQ1 were checked for nonlinearity along the logit, but none were evident (see Field, 2009, p. 296). Casewise diagnostics indicated that >94% of all cases in the regression models had standardized residuals within a ±2 limit, hence within 1% of what one might expect (Field, 2009, p. 244). All predictors were tested for bivariate and multivariate outliers, in addition to multicollinearity (cf., section 3.4.2 for details on the procedure). Initially, the credits from higher education variable was chosen a predictor, but the preliminary analyses indicated a strong linear relationship with the study programmes (<60 Credits vs. Education, $r = .780$, $n = 151$, $p < .001$, VIF = 9,548, tolerance = .106; and ≥300 Credits vs. Medicine, $r = .825$, $n = 151$, $p < .001$, VIF = 9,813, tolerance = .102). It was therefore decided that the variable should be removed from analyses associated with the research questions (cf., Tabachnick & Fidell, 2007, p. 125)

On the premise that regression analysis can only be conducted with continuous or dichotomous predictors the categorical items were recoded into indicator variables (Tabachnick & Fidell, 2007, p. 119); with *Medicine, Females aged 25 years and older* and *Grades better than B but less than A* chosen as baseline categories for their respective groups. Medicine was chosen, not only because it was the most populated of the study programmes, but also as a result of the difference in means between this group and the others. The age and gender group was the largest and chosen for the reason that it was best represented in all the study programmes. The same logic went for the grades group (cf., Table 1).

Finally, due to the aforementioned convenience sampling (see section 3.1), which is a breach of the random sampling assumptions for the parametric techniques used, the purpose was not to seek generalization for the wider population, id est it is not implied in any way that the students in the current study represents their discipline as a whole (e.g., that medicine students generally share negative attitudes toward multimodal presentations). Still, it is plausible that some of the results may indicate tendencies found among students in higher education (e.g., younger females are generally more positive to multimodal presentations than older males).

3.4.4.3. Phase I: Attitudes (AtMP and AtTL). The criterion variables for RQ1-4 was AtMP and AtTL, and an initial question, the main predictor of interest, was whether students from the different study programs (psychology, dentistry, education and medicine) would differ in attitudes. The analysing strategy was crafted on three steps, 1) to identify predictor variables functioning as contributors or detractors of students' attitudes through correlations, on the basis of three *continuous* variables (reported students media literacy, reported lecturers media literacy and reported students' understanding of their lecturers' didactical awareness) and three *categorical* variables (study programme, grade average from upper secondary education and gender across two age groups); 2) investigate, through multiple regression, whether study programme would be able to predict a significant amount of the variance in students' AtMP/AtTL; 3) and lastly investigate, through hierarchical multiple regression, whether study programme would *still* be able to predict a significant amount of the variance in AtMP/AtTL when controlled for the possible effects of variables in step one. The media literacy items were measured on a scale from zero (no skills) to six (highly skilled), whereas the didactical awareness item was measured on a 7-point Likert-type scale where 3 = completely agree; 2 = strongly agree; 1 = slightly agree; 0 = neither or; -1 = slightly disagree; -2 = strongly disagree; and -3 = completely disagree.

3.4.4.4. Phase II: Perceptions (AtMP vs. CTML). The criterion variables for phase II were the multimedia, modality, temporal contiguity and signaling principles. These were measured on the same scale as AtMP and AtTL, but were recoded into binary variables for RQ5-7 (see Appendix C-11), where 1 = completely agree; 2 = strongly agree; 3 = slightly agree was recoded into 1 (i.e., yes), and 4 = neither or; 5 = slightly disagree; 6 = strongly disagree; and 7 = completely disagree was recoded into 0 (i.e., no). The decision to reduce the Likert-scales into continuous dichotomies was not a preferred option, but a necessity due to a non-normal distribution and numerous outliers within the four criterions. The approach was deemed questionable not only because of the inevitable data loss (i.e., precision), but also in relations to ethical concerns. Forcing the respondents into either of the two categories implied making decisions on their behalf, decisions they might not identify themselves with. It must therefore be noted that the respondents may have answered otherwise if they had been confronted with a yes-no alternative.

RQ5 set out to examine, through biserial correlation if there was a relationship between AtMP and the four aforementioned principles. RQ6 used bivariate logistic regression to inspect if AtMP could predict students' standpoint regarding the four criterion variables, whereas the final research question, RQ7, used multivariate logistic regression as a mean to investigate if AtMP could still predict a significant amount in the criterion variables, when controlled for the possible effects of variables from RQ1 and RQ2.

3.5. Ethical considerations

On June 26th an application, accompanied by a project plan and the early questionnaire draft was sent to the Norwegian Social Science Data Services (NSD). The NSD serves as a personal data protection official for research conducted in Norway, and "puts emphasis on disseminating knowledge of the legal and ethical guidelines regulating research" (NSD, n.d.). The following week, on July 7th, the application was approved stating that, "after reviewing the information provided in the application and other documentation, we find that the project does not involve a licensing requirement" (see Appendix A). The NSD concluded that the research design did not involve student names, student numbers or email addresses, and that the combined demographical data could not be used to identify the individual respondent. Still, the researcher followed the board's recommendation that the age variable ought to be coarsely categorized.

A key ethical concern was that of informed consent, which is as an essential part of conducting the study in a thorough and correct manner (cf., L. Cohen et al., 2011, p. 103). Indeed, a potential ethical dilemma could be found in the nature of the data collection. The use of the personal response system entailed that the respondents were completely anonymous, even for the researcher. One of the main elements of informed consent is voluntarism, and so the right to discontinue participation at any given time (L. Cohen et al., 2011, p. 78). If a respondent were inclined to leave the project after the data collection, the anonymous nature of the research design would make this difficult, but not impossible given the small samples from each study programme. The details concerning informed consent have otherwise been described in 3.3, and additional ethical notions on the conduct of research have been raised throughout this chapter.

4. Results

This chapter presents the results from the data analyses and is divided into eight main sections, starting with a descriptive overview of the study as a whole and followed by seven segments representing each of the seven research questions (cf., Table 6). Albeit, demographics have been covered in the preceding chapter, it would still be appropriate to augment with some notes on the other variables related to the research questions, in addition to a general summary of students' perception of instructional medium, lecture formats and learning outcome.

Though most of the tabular and graphical presentations are found in Appendix C, some will be presented in this chapter as well. All data depicted in this chapter are based on self-reports by students.

Table 6
Summary of Research Questions and Data Analyses

#	Research question	Analysis
1	What relationship exists, if any, between students' AtMP/AtTL and reported student and lecturers' media literacy and students' understanding of their lecturers' didactical awareness?	Pearson's Correlation
2	Is there a significant difference in students' AtMP/AtTL between study programmes, grade average from upper secondary education and across gender in different age groups?	ANOVA
3	Are the study programmes able to predict a significant amount of the variance in students' AtMP/AtTL?	Multiple Regression
4	If controlled for the possible effect of variables from RQ1 and RQ2 will study programme be able to predict a significant amount of the variance in students' AtMP/AtTL?	Hierarchical Multiple Regression
5	What relationship exists, if any, between students' AtMP and students' standpoint regarding the multimedia, modality, temporal contiguity and signaling principle?	Biserial Correlation
6	Can AtMP predict a significant amount of the variance in students' standpoint regarding the CTML principles?	Bivariate Logistic Regression
7	If controlled for the possible effect of variables from RQ1 and RQ2 will AtMP be able to predict a significant amount of the variance in students' standpoint regarding the CTML principles?	Multivariate Logistic Regression

4.1. Descriptive and Preliminary Inferential Statistics

A large majority of the respondents reported that PowerPoint was the most frequent used instructional medium (74.2%, n = 121), in contrast none reported that traditional lectures was used as a sole medium. Only two students (1.2%) reported that the lectures spent most time on traditional lectures when the two mediums were used together, whereas almost a quarter of the respondents (23.9%, $n = 39$) stated the opposite. It is therefore clear, according to the students in this study, that PowerPoint is a dominant feature of their lectures. The responses regarding the students' preferred lecture format were more diverse, though centred around two main groups. A bulk of the students (57.7%, $n = 94$) preferred monologue, dialogue and discussion between students, or the former in addition to case studies, while a smaller group (38.6%, $n = 64$) preferred monologue or a mixture of monologue and dialogue. It would be inappropriate to make any inferences based on these figures, but it may reflect differences concerning preferences toward either a lecture-based or student-centred learning environment (Baeten, Struyven, & Dochy, 2013).

When asked what they believed was the main intent behind their lectures' use of multimodal presentations (teaching intentions) the students' were dispersed within a number of categories (see Appendix C-10). The three largest groups were divided between that the students should *remember the subject matter* (28.8%, $n = 47$), that they should *understand the subject matter* (30.1%, $n = 49$), while nearly a quarter of the students (22.7%, $n = 37$) answered that they *did not know*. There was no on-face relationship between preferred lecture format and students' perception of teaching intentions, nevertheless there were some interesting observations associated with the four study programmes and the latter subject. Teaching intentions was recoded into four categories, where *apply*, *analyse*, *evaluate* and *create new understanding of the subject matter* were collapsed into the category *other* (see Appendix C-12). A Chi-square test for independence with 4x4 contingency tables was conducted between the newly reformed item and study programme, and indicated a significant association between the two (χ^2 (9) = 27.56, $p < .001$). It is worth noticing that 59.5% of those responding *don't know* came from medicine, totalling 36.7% ($n = 22$) of the students from this study programme. Bear in mind that these were medicine graduates (see Figure 3).

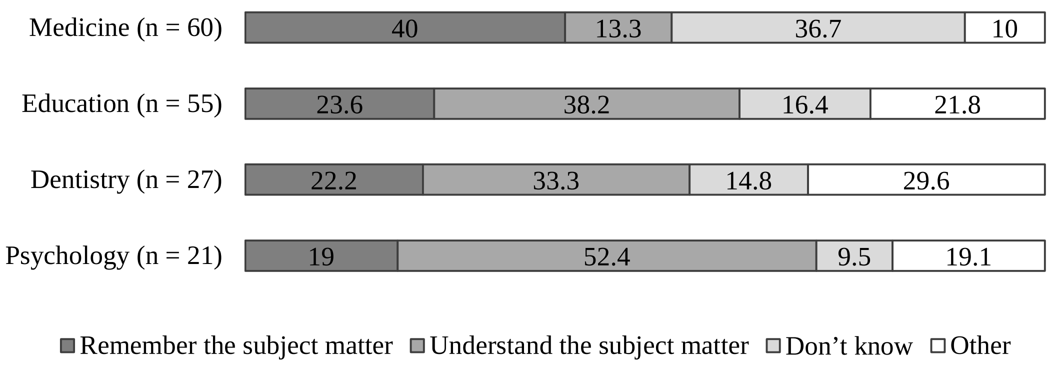

Figure 3. Intentions with multimodal presentations as perceived by students. Per cent.

Additionally, an ANOVA was conducted between AtMP and teaching intentions, indicating that there were statistical significant differences between the four groups (F (3, 156) = 7.56, $p < .001$, $\omega^2 = .11$) with a medium effect size. As can be seen from Figure 4, the understanding (n = 49, M = 3.35, SD = 5.73) and transferal (n = 30, M = 3.83, SD = 5.91) groups, differed significantly from the retention (n = 44, M = -0.23, SD = 5.21) and do not know (n = 37, M = -1.11, SD = 5.65) groups.

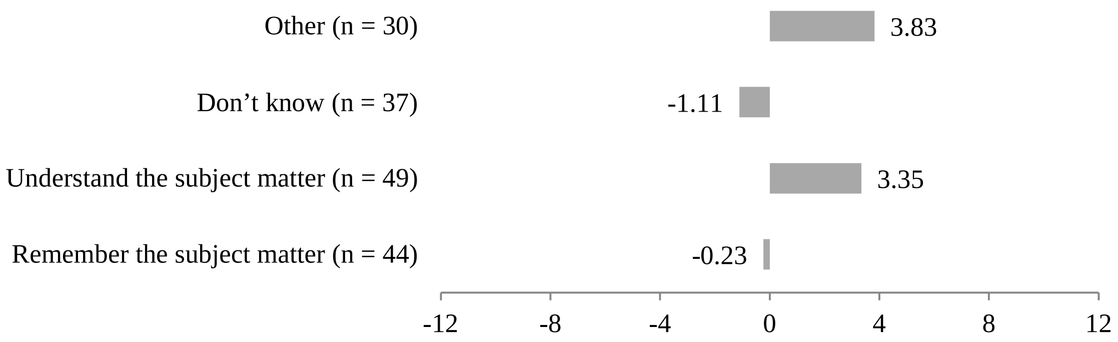

Figure 4. AtMP by teaching intentions with multimodal presentations. Mean.

Moreover, when asked about their opinion on how PowerPoint was used, nearly half (46.9%, n = 76) answered that the most common usage was written text and graphics in combination with oral text (basic multimodal). Approximately a third of the students (33.3%, n = 54) replied that presentations were commonly written text only; with 10 (6.2%) students adding that written text was used in tandem with oral text (unimodal). Less than 10% (9.3%, n = 15) answered that animations and/or videos (complex multimodal) were part of the regular usage. By way of contrast, 54.0% (n = 88) of the respondents answered that they believed a presentation with complex multimodal would be best for their learning outcome (see Appendix C-14). Thus, for many of the students there is a notable discrepancy between perceived needs and observed availability (see Figure 5). As a curious side note one could mention that though medicine students scored quite low on the AtMP scale, and seemingly favoured traditional lectures (cf., Appendix C-7), 54.2% (n = 32) of the students answered that a complex multimodal presentation would be best for their learning outcome.

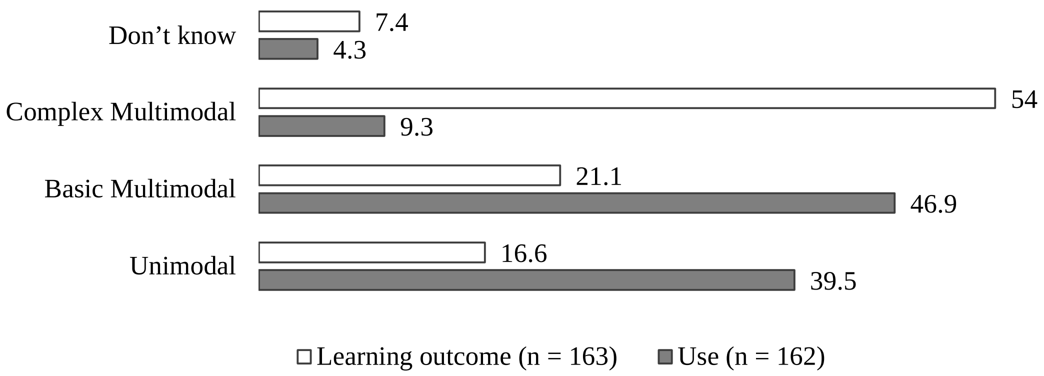

Figure 5. Perceived use and learning outcome by multimodal presentations. Per cent.

4.1.1. Media literacy and didactic awareness. A subject of interest prior to the study was whether media literacy, both among lecturers and students, shared a relationship with students' attitudes toward lectures involving digital or analogue instructional mediums. The students were asked to rate both their own and their lecturers computer skills on a scale from zero (no skills) to six (highly skilled), and according to the results the students considered their own media literacy to be intermediate (n = 165, M = 3.50, SD = 1.02), with no significant differences between the study programmes (F (3, 161) = 0.80, p = .49). The lecturers were rated more than a unit lower (n = 162, M = 2.41, SD = .99), though there were significant differences between the study programmes (F (3, 158) = 10.72, p < .001). The students from psychology (n = 21, M = 3.24, SD = .77) rated their lecturers highest, almost equalling their own scores, and differed significantly from all the other programmes. Education (n = 56, M = 2.60, SD = .99) differed both from psychology and medicine (n = 59, M = 2.00, SD = .87), whereas dentistry (n = 27, M = 2.26, SD = .98) were different only in relation to psychology (see Appendix C-9). The effect size was calculated according to the equation in Appendix D-1, resulting in a large effect of ω^2 = .15, which indicates that 15% of student opinions regarding their lecturers' media literacy could be accounted for by the study programmes.

Furthermore, the students were asked to what extent they agreed that their lectures were aware of current research on how students' best learn from plenary lectures (didactic awareness). The answers were measured on a 7-point Likert-type scale ranging from complete disagreement to complete agreement (cf., section 3.4.4.3). The overall response indicated that the students' opinions were found between neutral and a mild disagreement (n = 164, M = -0.59, SD = .13), but an ANOVA revealed significant differences between the study programmes (F (3, 160) = 48.56, p < .001, ω^2 = .33). Psychology (n = 22, M = .50, SD = 1.44) and education (n = 55, M = 0.58, SD = .96) leaned toward a slight agreement, with no significant differences between the two programmes. Dentistry (n = 27, M = -0.96, SD = 1.29) was significantly different from the two aforementioned groups exhibiting a slight disagreement. In addition, dentistry also differed significantly from medicine (n = 60, M = -1.88, SD = 1.29), which in turn strongly disagreed with the statement (see Figure 6).

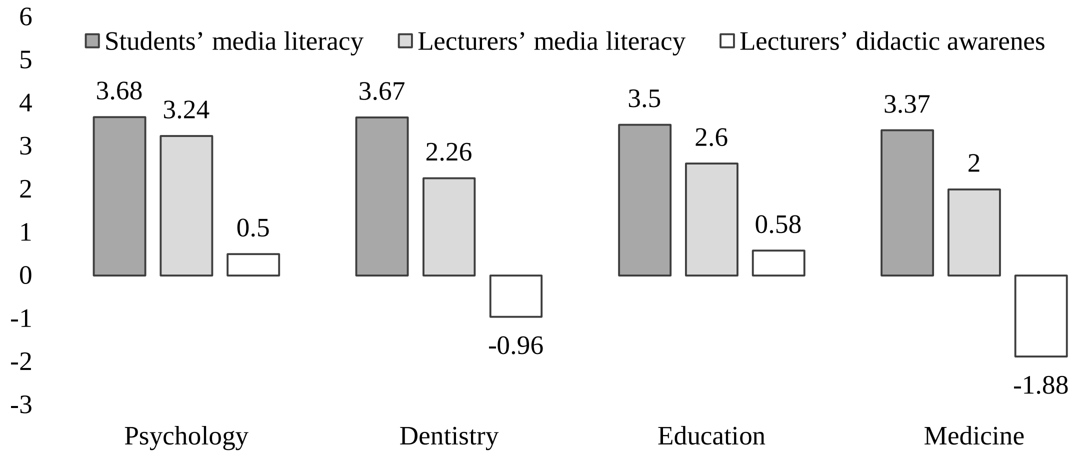

Figure 6. Media literacy and didactic awareness across study programmes. Mean.

The observation found support in a comparison between didactic awareness and accumulated credits from higher education (*Welch's F* (2, 95.93) = 74.54, p < .001, $est.\omega^2$ = 0.48). The Welch's F-ratio was used as a Levene's test revealed that the assumption of homogeneity of variance was violated, and accordingly an $est.\omega^2$ was calculated (cf., Appendix D-2). Students with 0 – 59 credits from higher education (n = 40, M = 0.80, SD = .94) differed significantly both from those with 60-299 credits (n = 48, M = -0.02, SD = 1.41) and 300 credits or more (n = 74, M = -1.72, SD = 1.29). The latter two groups were also significantly different from each other. Thus, 33% and approximately 48% of the total variance in the students' opinion of their lecturers' didactic awareness could be accounted for by study programmes and credits from higher education respectively.

4.1.2. AtMP and AtTL. The main catalyst behind this study was a wish to measure students' attitude toward multimodal (AtMP) and traditional lectures (AtTL). Indeed, the preceding chapter spent most of its passages describing the composition of the scales. According to the average means there were no seemingly differences between AtMP (n = 162, M = 1.42, SD = 5.93) and AtTL (n = 158, M = 1.12, SD = 6.18). However, large standard deviations indicated that the students were spread over a wide range of scores and a scatterplot identified a negative linear relationship between the two scales. A Pearson's correlation, accompanied by a student's *t*-distribution test was conducted (cf., Appendix D-3), which supported the graphical assessment (r = -.81 n = 155, $p < .001$, R^2 = 65.6%). With 155 respondents equalling and alpha set at .0005, the critical value of the *t*-distribution is ±3.3552. Thus, there was less than 0.05% probability of these results occurring if there was no relationship between AtMP and AtTL. The results were as such statistical significant. Moreover, the coefficient of determination (R^2) equalled 0.656, and so 65.6% of the total variance in each variable was accounted for by the other. A frequency diagram (see Figure 7) supported the claim, and gave a clear indication that medicine differed from the other study programmes. As can be seen from Appendix C-5 and Appendix C-6 there was a consistency in the answers given to each of the AtMP and AtTL sub-items. AtMP scored especially well on the items measuring structure and learning outcome, but with the exception of the students from education, AtTL scored highest on interaction between student and lecturer.

The relationship between AtMP, AtTL and the predictor variables will be further examined through research question one through four.

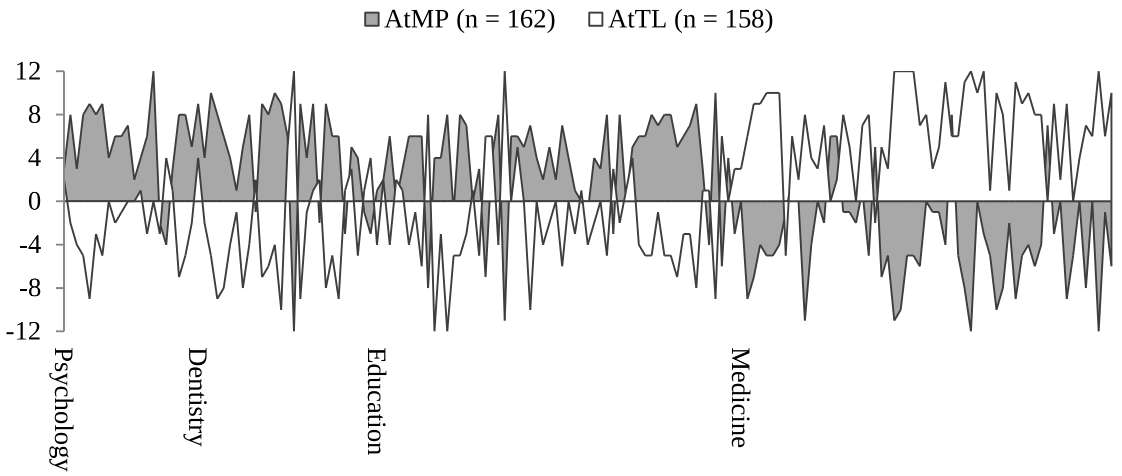

Figure 7. AtMP and AtTL frequencies by cases and study programmes.

4.1.3. Four principles of CTML. As outlined in section 3.2.1 the Cognitive Theory of Multimedia Learning was chosen as a theoretical framework for this study (see Chapter two for a review). Furthermore, the specifics regarding the four CTML principles chosen as criterion variables for research question five through seven have been described in section 3.4.4.4. The students were given four statements asking to what extent they agreed that the multimedia, modality, temporal contiguity and signaling principle would be better for their learning outcome. Appendix C-11 gives a detailed overview of the answers provided by the students, and it is clear that most either agreed to some extent with, or were neutral toward the given statements. The clear exception was the *modality principle* (*n* = 161), and when the item was recoded into a binary variable, a majority of students (*n* = 88, 54.7%) answered that they did not learn any better from simultaneously use of oral text and graphics than from simultaneously use of written text and graphics. Conversely, the *signaling principle* (*n* = 162) had the largest support among the students, with 96.3% (*n* = 156) of the respondents claiming they learned better when cues that highlight the organization of the essential material were added to the presentation. The students were also mostly positive toward the *multimedia principle* (*n* = 163), where 82.8% (*n* = 135) agreed that they learn better from words and graphics than from words alone. Lastly, the *temporal contiguity principle* (*n* = 165) was supported by 71.5% (*n* = 118) of the students, leaving more than a quarter (*n* = 47, 28.5%) opposed to the notion that they learn better when corresponding words and graphics are presented simultaneously rather than successively (see Figure 8). Research question five through seven seek to examine a potential relationship between AtMP and the four criterion variables, though it should be noted that the homogenous composition of the answers regarding the multimedia and signaling principle severally impairs the usefulness of inferential statistics.

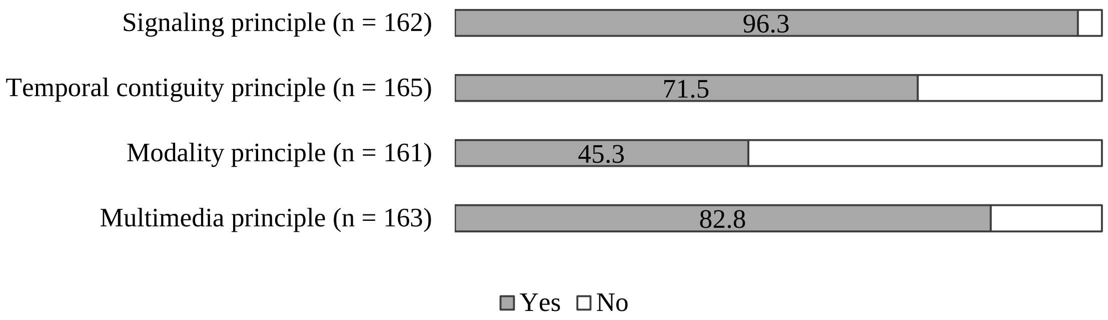

Figure 8. Students' perception of four principles within CTML. Per cent.

4.2. RQ1: Pearson's Correlation

Three pairwise Pearson product correlations were conducted for both AtMP and AtTL (see Table 7). The results indicated that there was no significant relationship between students' media literacy and AtMP and AtTL. On the other hand, media literacy among the lecturers had a medium positive relationship with AtMP (R^2 = 12.96%, $p < .001$) and a weak negative relationship with AtTL (R^2 = 6.76%, $p < .001$). The item measuring the students' assessment of their lectures didactical awareness had a medium positive relationship with AtMP (R^2 = 24.01%, $p < .001$), and equally a medium negative relationship with AtTL (R^2 = 21.16%, $p < .001$). Hence, the higher the students' rating of their lecturers' didactical awareness and media literacy, the more likely they were to have a positive attitude toward multimodal presentations and subsequently a negative attitude toward traditional lectures. It should be noted that the medicine students had a severe impact on the results, and if removed from the equation only lecturers' media literacy with AtMP was still statistically significant ($r = .27$, n = 102, $p = .006$, R^2 = 7.29%). The other coefficients maintained the same direction, but were both statistical insignificant and weak. Furthermore, there was also a significant positive relationship between students' perception of their lecturers' didactical awareness and the lecturers' media literacy ($r = .33$ n = 161, $p < .001$, R^2 = 10.89%). This relationship was still observable when the medicine students were removed (r = .25, n = 102, p = .012, R^2 6.25%).

Table 7
AtMP and AtTL Correlations with Media Literacy and Didactic Awareness

Scale	Media Literacy (Student)	Media Literacy (Lecturer)	Didactical Awareness
AtMP	.05 (162)	.36* (159)	.49* (161)
AtTL	-.07 (158)	-.26* (156)	-.46* (157)

Note. $^{*}p \leq .001$ level (2-tailed).
Subsample size (*n*) appears in parentheses beside correlation coefficients.

4.3. RQ2: ANOVA

To investigate whether differences between the four study programmes could explain any of the variance in the two criterion variables, a one-way analysis of variance (ANOVA) was conducted for both AtMP and AtTL (see Table 8). As predicted by the descriptive analyses, three of the study programmes (psychology, dentistry and education) differed significantly from medicine ($p < .001$) but not from each other. The two ANOVA models were also significant: AtMP: F (3, 158) = 37.01, $p < .001$ and AtTL: F (3, 154) = 48.47, $p < .001$. The difference was slightly larger for AtTL (ω^2 = 47%) than AtMP (ω^2 = 40%), though both indicated a large effect size. The implications of the results were that while students from psychology, dentistry and education favoured multimodal presentations over traditional lectures, medicine students leaned toward a strong preference of the latter.

Table 8
AtMP and AtTL by Study Programme

	Study programme						
Scale	Psychology	Dentistry	Education	Medicine	Total	*F*	ω^2
AtMP	5.55_{d} (3.75)	4.37_{d} (5.22)	3.62_{d} (4.52)	-3.60_{abc} (4.63)	1.42 (4.93)	37.01*	.40
n	22	27	55	58	162		
AtTL	-2.05d (3.49)	-2.74_{d} (5.38)	-1.87_{d} (5.79)	6.74_{abc} (3.96)	1.12 (6.18)	48.47*	.47
n	19	27	54	58	158		

Note. $^{*}p < .001$ level (2-tailed).
Standard deviations appear in parentheses beside means.
Means with differing subscripts within rows are significantly different at the $p < .001$ based on Bonferroni and Games–Howell post hoc paired comparisons.

Similar to the procedure above, an ANOVA for each of the criterion variables was conducted between grade averages from upper secondary education (see Table 9). Levene's test for homogeneity of variances was significant, signifying that the standard deviations between the groups were heterogeneous. As a result, Welch's *F*-ratio was used to test if there were differences between the three grade groups. According to the results, students that had D or better, but less than C, and also students with C or better, but less than B, differed from students with B or better ($p < .001$) but not from each other. The models, AtMP (Welch's F (2, 76.14) = 22.37, p < .001, $est.\omega^2$ = 21%) and AtTL (Welch's F (2, 63.89) = 27.28, p < .001 $est.\omega^2$ = 25%) were significant, both indicating a large effect size. Due to the overrepresentations of medicine students in the B or better group, a pattern could be detected between study programmes and grade average. Still, the means were lower for the current models, implying that higher grades do not necessarily entail a homogenous presupposition regarding the two criterions. The reasoning was supported by the results indicating that there are no significant differences between the groups when the medicine students were removed from the equation (Welch's F (2, 61.99) = .59, p = .56, $est.\omega^2$ = 0.8%).

Table 9

AtMP and AtTL by Grade Average from Upper Secondary Education

	Grade Average from upper secondary education					
Scale	≥D<C	≥C<B	≥B<A	Total	Welch's F	$est.\omega^2$
AtMP	4.25_c (3.18)	4.47_c (4.15)	-0.89_{ab} (6.15)	1.32 (5.89)	22.37*	.21
n	24	43	93	160		
AtTL	-2.74_c (4.30)	-2.29_c (3.88)	3.65_{ab} (6.24)	1.13 (6.20)	27.28*	.25
n	23	42	92	157		

Note. *p < .001 level (2-tailed).
Standard deviations appear in parentheses beside means.
Means with differing subscripts within rows are significantly different at the p < .001 based on Bonferroni and Games–Howell post hoc paired comparisons.

A final ANOVA was conducted between the criterions and gender in two different age groups (see Table 10). Once more the Levene's test was significant, requiring the use of Welch's F-ratio. The two models: AtMP (Welch's F (3, 71.80) = 27.91, p < .001, $est.\omega^2$ = 34%) and AtTL (Welch's F (3, 70.57) = 23.01, p < .001, $est.\omega^2$ = 30%) were significant and the effect size was calculated to be high. In contrast to the analyses involving study programmes and grade average from upper secondary education, the between group differences were more complex. For both scales females aged 19-24 and males aged 19-24 differed from their older counterparts (p < .05), whereas females aged 25 or older differed from males aged 25 and older for AtMP (p < .05), but not for AtTL. When the medicine students were removed from the equation there were no significant differences between the groups for AtTL (F (3, 96) = 1.26, p = .29, ω^2 = 0.77%), however for AtMP (F (3, 99) = 2.77, p = .046, ω^2 = 4.90%) there was a significant difference between males 25 years and older (n = 10, M = .40, SD = 3.84) and females aged 19-24 (n = 53, M = 4.83, SD = 4.58) at p = .031. The effect size was nevertheless calculated to be small, and the small male subsample should also be noted.

Table 10
AtMP and AtTL by Gender in Different Age Groups

Scale	Gender in different age groups: Female (19-24)	Female (≥25)	Male (19-24)	Male (≥25)	Total	Welch's *F*	*est.ω*^{2}
AtMP	4.85_{bd} (4.54)	$-.04_{acd}$ (6.03)	4.53_{bd} (2.99)	-3.50_{abc} (4.79)	1.42 (5.96)	27.91*	.34
n	52	53	19	34	160		
AtTL	-2.65_{bd} (5.08)	2.75_{ac} (6.27)	-1.44_{bd} (3.15)	5.51_{ac} (4.90)	1.10 (6.19)	23.01*	.30
n	52	52	18	35	157		

Note. *$p < .001$ level (2-tailed).
Standard deviations appear in parentheses beside means.
Means with differing subscripts within rows are significantly different at the $p < .05$ based on Bonferroni and Games–Howell post hoc paired comparisons.

4.4. RQ3: Multiple Regression

A multiple regression analysis was conducted for each of the AtMP and AtTL scales with psychology, dentistry and education as indicator variables and medicine as a baseline category. Since multiple regression with a polytomous categorical variable is essentially an ANOVA, the preceding section had hitherto established that the regression models for AtMP (F (3, 158) = 37.01, $p < .001$) and AtTL (F (3, 154) = 48.47, $p < .001$) were statistically significant. As can be seen from Table 11 and Appendix C-7, the constant, or intercept (B_0) of AtMP is the mean of the baseline group (i.e., the medicine students) within the study programmes. The unstandardized coefficient (B) of each indicator is the difference between the constant and the mean of the respective variable (Field, 2009, p. 259). The calculations can be found in Appendix D-6 through Appendix D-11, which revealed that 41% of the variance in AtMP, and 49% for AtMP could be explained by their respective models. The preceding ANOVA demonstrated that students from psychology, dentistry and education differed significantly from medicine students, which the regression coefficients also suggested.

Table 11
AtMP and AtTL Predicted by Study Programme

Predictors	AtMP [a] (*n* = 162) *B*	*SE B*	*β*	AtTL [b] (*n* = 158) *B*	*SE B*	*β*
Constant	-3.60	0.60		6.74	0.59	
Study programme						
Psychology vs. Medicine	9.15	1.15	.53*	-8.79	1.18	-.47*
Dentistry vs. Medicine	7.97	1.07	.50*	-9.48	1.04	-.58*
Education vs. Medicine	7.22	0.86	.58*	-8.61	0.85	-.66*

Note. [a] $R^2 = .41$, $F = 37.01$*.
[b] $R^2 = .49$, $F = 48.47$*.
*$p < .001$.

4.5. RQ4: Hierarchical Multiple Regression

A final phase in assessing AtMP and AtTL involved a hierarchical multiple regression for each of the criterions (see Table 12). The first sequence dealt with the interactions between gender from two age groups, grade average from upper secondary education, lecturers' didactic awareness and lecturers' and students' media literacy, whilst the full model also included the four study programmes. The analyses were meant to assess whether the study programmes could significantly increase the coefficient of determination when compared to the first sequence, secondly to identify statistically significant predictors in the full model, and thirdly to predict the values of the criterions.

Table 12
AtMP and AtTL Controlled

	AtMP [a] (n = 155)			AtTL [b] (n = 158)		
	B	$SE\ B$	β	B	$SE\ B$	β
Predictors step 1						
Constant	-2.69	1.58		5.09	1.78	
Gender by age						
Female (19-24) vs. Female (≥25)	2.37	1.06	.19*	-2.44	1.15	-.19*
Male (19-24) vs. Female (≥25)	1.46	1.41	.08	-0.53	1.56	-.03
Male (≥25) vs. Female (≥25)	-3.76	1.08	-.26***	3.72	1.15	.25**
Lecturers' Didactic Awareness	0.76	0.29	.21**	-0.60	0.32	-.16
Lecturers' Media Literacy	1.14	0.40	.19**	-0.56	0.43	-.09
Students' Media Literacy	0.27	0.38	.05	-0.49	0.43	-.08
Grade Average						
≥D<C vs. ≥B<A	1.18	1.26	.07	-3.10	1.37	-.18*
≥C<B vs. ≥B<A	1.76	1.06	.13	-2.88	1.16	-.20*
Predictors step 2						
Constant	-3.55	1.50		6.84	1.62	
Gender by age						
Female (19-24) vs. Female (≥25)	1.54	1.04	.12	-0.82	1.09	-.06
Male (19-24) vs. Female (≥25)	0.89	1.34	.05	0.79	1.42	.04
Male (≥25) vs. Female (≥25)	-3.23	0.99	-.22***	2.86	1.02	.19**
Lecturers' Didactic Awareness	0.63	0.28	.17*	-0.33	0.30	-.09
Lecturers' Media Literacy	1.01	0.37	.17**	-0.40	0.39	-.06
Students' Media Literacy	0.07	0.35	.01	-0.29	0.37	-.05
Grade Average						
≥D<C vs. ≥B<A	3.44	1.46	.21*	-4.28	1.53	-.25**
≥C<B vs. ≥B<A	2.90	1.17	.22*	-3.25	1.25	-.23*
Study programme						
Psychology vs. Medicine	2.98	1.62	.17	-4.32	1.74	-.23*
Dentistry vs. Medicine	5.51	1.10	.35***	-7.75	1.14	-.48***
Education vs. Medicine	0.19	1.64	.02	-3.00	1.71	-.23

Note. [a] R^2 = .44, ΔR^2 = .11, F = 14.19***, ΔF = 11.71***.
[b] R^2 = .40, ΔR^2 = .16, F = 11.80***, ΔF = 16.64***.
*$p \leq .05$, **$p \leq .01$, ***$p \leq .001$.

4.5.1. AtMP. The first sequence explained 44% (F (8, 146) = 14.19, $p < .001$) of the variance in AtMP, whereas the model as a whole explained 55% (F (11, 143) = 15.78, $p < .001$). Hence, study programme contributed with additional 11% when controlled for the effects of the other predictor variables ($\Delta R^2 = .11$, ΔF (3, 143) = 11.71, $p < .001$). The final model included six statistical significant predictors at $p \leq .05$, where lecturer's didactical awareness and lecturers' media literacy were defined as moderators of the other predictor variables. According to the correlation analysis from RQ1 the two variables shared a moderate positive linear relationship, and as consequence it would be natural to assume that an increase in one would equal an increase in the other. Though the two variables were measured on a seven-point scale, they were not weighted equally. Lecturer's didactical awareness was measured at ±3, whereas lecturer's media literacy was on a 0-6 point scale. Therefore, the minimum level would be -3 and 0 for the two variables respectively. Students' media literacy was also considered a moderator, but since it was not deemed statistical significant the variable was held constant. To limit the number of potential scenarios it was decided to level the moderating variables at equal terms. Thus, using Equation 5 one may predict students' attitude toward multimodal presentations. It should be noted that some of the possible prediction scenarios are highly unlikely, for instance it is clear from the descriptive statistics that most students from both medicine (n = 58, 98.3%) and dentistry (n = 24, 88.9%) have B or better, but less than A in average grades from secondary education. Consequently the influence of grade average is limited on these two groups.

Still, using the formula above one may calculate the predicted value of AtMP for each combination of predictors, and also the variance in criterion based on a one-unit change in the significant moderator variables. The moderating effect is simply the sum of the unstandardized regression coefficients for lecturers' didactic awareness and media literacy, which is 1.64. Hence, if the predicted scenario involved a female medicine student, presumable aged 25 years or more and with a grade average of B or better, the probable minimum outcome would be -5.43, with a maximum of 4.37 when the other predictors are held at zero (M = -2.48, SD = 1.11). An error rate (ε) based on the difference between predicted and observed values of AtMP was calculated for the sample as a whole (M = 1.91, SD = 3.49) and revealed four outliers that were not adequately predicted by the model, but the sample was otherwise normally distributed

Lastly, it is important to remember that the statistical significance of each listed indicator variable is reliant on its baseline category. To measure the various combinations one can simply calculate the difference between two indicators and use Appendix D-10 to assess the significance. This co-dependency is not present for the moderator variables, and since the regression model is additive and linear, the values of a one-unit change in the moderator variables are constant for all the predicted scenarios even if one or more baseline categories of the indicator variables were to be altered. As such, the difference between each combination would be the same at every unit change.

Since the constant is negative, with only one negative coefficient (males ≥25 years), one may assume that the baseline categories share attributes that correlate with negative attitudes toward multimodal presentations. When controlled for the other variables there were no significant differences between females aged 25 years and older and their younger counterparts, whereas their male peers was significantly more averse to the presentational format. Concerning the three average grade groups there was a statistical significant and negative difference between students having B or better in relation to the others, while there was none to be observed among the latter two groups. The medicine students differed negatively from the other study programmes, but were only significantly different from dentistry. Psychology and dentistry were not statically divergent for each other, but had a statistically significant higher score than education on the AtMP scale. As a result, one may gauge from the current model that older males studying medicine were the most sceptical, whereas younger females studying psychology, with grades lower than B, had the most positive attitudes toward multimodal presentations when controlled for the other predictors in the model.

4.5.2. AtTL. Equal to the preceding section, a model intended to predict the outcome of AtTL was built using the same predictors. An initial overview revealed a mirrored model to AtMP, though the study programmes explained an additional of 5% compared to the aforementioned scale ($\Delta R^2 = .16$, $\Delta F\ (3, 158) = 16.64$, $p < .001$). The first step in the model explained 40% of the variance ($F\ (8, 144) = 11.80$, $p < .001$), whereas the full model explained 55% ($F\ (11, 141) = 15.92$, $p < .001$). The main difference between the AtMP and AtTL regression models were the influence of the moderator variables. For the AtTL scale these were of no statistical significance, meaning that they had no major impact on the students’ attitude toward traditional lectures.

The significant indicator variables indicated that while males aged 25 and older had a higher AtTL score than their female peers, the influence of grade average was also greater for AtTL than AtMP. Students from dentistry were significantly different from all the other students and scored lowest on the AtMP scale, whereas medicine students at the other end also differed from those in psychology, but not education. The error rate (M = 2.08, SD = 3.58) had a normal distribution, but included five outliers.

4.6. RQ5: Biserial Correlation

To assess if there was a relationship between AtMP and the four outlined multimedia principles, a biserial coefficient was calculated between the principles and AtMP using the equations from Appendix D-4 and Appendix D-5 (see Table 13). The Procedure indicated that there was a weak positive relationship between AtMP and the modality (R^2 = 7.84%) principle and likewise a medium positive relationship between AtMP and the temporal contiguity principle (R^2 = 9.61%). Both, according to the computed z-score, were statistically significant at $p < .01$. Additionally, a positive relationship was found with AtMP and the signaling (R^2 = 7.84%) and multimedia principle (R^2 = 1.69%), but the results were not significant. Overall the results indicated that the higher the students' score on the AtMP scale the higher the likelihood that he or she would answer yes to the statements regarding the four principles.

Table 13
AtMP Biserial Correlation with Four CTML Principles

Scale	Multimedia	Modality	Temporal Contiguity	Signaling
AtMP	.13 (161)	.28* (158)	.31* (162)	.28 (160)

Note. *$p < .01$ level (2-tailed).
Subsample size (n) appears in parentheses beside correlation coefficients.

4.7. RQ6: Bivariate Logistic Regression

To further inspect whether there was a relationship between AtMP and the four CTML principles a bivariate logistic regression was conducted for each of the criterions. As expected from the descriptive statistics and biserial correlations, the regression models for the multimedia and signaling principle were insignificant and the corresponding table containing the two items was therefore relocated to the appendices (see Appendix C-15). It was mentioned in section 3.4.4.1 that the calculation of the unstandardized coefficients in logistic regression is a rather cumbersome and complex procedure, and as a result are the values computed by SPSS. The following section will demonstrate the regression calculations between AtMP and the modality principle, but the methods are also applicable for multivariate and additive sequential solutions (see Appendix D-12 through Appendix D-14).

The first step in evaluating the model is to calculate the intercepts influence on the baseline model, and in a model without any predictors the intercept will always be the proportion of the largest group. Hence, for the current baseline model the probability ($\hat{p}$) of a student answering yes to the modality principle is $1/1+e^{-(-.0.1777)}$ = .4557 (cf., Figure 8). At this current stage the only variable in the equation is whether the student actually answered yes, and by using Appendix D-12 one may calculate the log-likelihood of the two outcomes.

The log-likelihood measures the density of observations in the sample, where deviances from zero signify unexplained variance (Menard, 2002, p. 20). The results indicated, as one might expect, that the unexplained variance was higher for the students who answered yes (λ_1) to the statement. The reason for this is simply that the baseline model had anticipated that all students would answer no as this was the group with the highest frequency. Initially, the model could therefore correctly predict 54.4% of the cases, with an aggregate log-likelihood of -108.8962. A comparison could be a coin toss, where a fair coin would have a $\hat{p}$ equalling .5 and a log-likelihood of ln(.5)×158 = -109.5173. To calculate the difference between models, one may subtract the baseline model (D_0) from the current model (D_i) and square the result for an approximation of a chi-square. The difference in this scenario would be 1.2421, which is less than the critical value of χ^2 (1) = 3.8415 = p > .5. Thus, the prediction of the baseline model is not significantly different from a coin toss.

By adding a continuous variable into the equation the procedure will grow more complex and similar to an additive linear regression $\hat{p}$ will now be the probability of Y when X is zero. As can be seen from the decreased unstandardized coefficient of the constant, the model predicts that a zero score on the AtMP scale will negatively affect the group size of students answering yes (see Table 14). Furthermore, a negative AtMP score will enhance the negative trend, whereas a positive score will counter it. To calculate the probability of the various outcomes one may use Appendix D-14. From the regression model and the composition of the AtMP scale one may assert that $\hat{p}$ can range between the extremes of .2243 (AtMP = -12) and .6564 (AtMP = 12). The average value has to be .4557 since the predicted value cannot be larger than the observed value. The equation above is set in an iterative process for the 158 cases (i.e., students) with a cut value of .5. The cut value indicates that $\hat{p}$ below .5 will be treated as zero and conversely values from .5 will be treated as one. This will lead to four possible scenarios where either the model predicts a true positive, a false positive, a true negative or a false negative. The results indicated that the model correctly predicted 23.42% of the true positives and 31.65% of the true negatives, totalling 55.07% correct predictions. Using Appendix D-12 the log-likelihood for the sample was calculated at -104.9901. Thus, by the logic presented above one may calculate the difference between the baseline and the full model as χ^2 (1) = 7.8122, hence statistically significant at $p < .10$.

An additional method to evaluate how the model fits the data is by calculating an approximation of R^2. Despite no consensus regarding the various calculations of pseudo-R^2 the study used three approaches which can be found in Appendix D-13 (cf., section 3.4.4.1). From the three equations one can assert that the model as a whole explained between 3.59% (Hosmer and Lemeshow's R^2_{L}), 4.82% (Cox and Snell's R^2_{CS}) and 6.44% (Nagelkerke's R^2_{N}) of the variance in the students' standpoint regarding the Modality principle. In other words, there is still between 93.56-96.41% of variance that is not accorded for.

Lastly one may asses the contribution and significance of each predictor using Appendix D-12 from the likelihood-ratio between D_i and D_k. Where the latter is D_i with a specified predictor excluded from the model. Since a bivariate logistic regression entails only one predictor, the likelihood-ratio test equals the difference between the full model and its baseline. Hence, the AtMP predictor is statistical significant at $p < .01$. To calculate the odds ratio (e^B) one may use Appendix D-14. The equation gives indication that a positive one-unit change in AtMP will increase the odds ratio of a student answering yes to the modality statement by 8.21%.

The aforementioned procedures were also used to measure the AtMP scales' ability to predict students' standpoint regarding the temporal contiguity principle. The predictor was poor at identifying students in the no-group, as the students' score would have to be at -10 to revoke the effect of having no attitudes toward multimodal presentations at all (AtMP = 0). Thus only 10.9% of the no-group was correctly identified. Contrariwise, the higher the AtMP score the greater the likelihood of students answering yes, and so 97.4% of the yes-group was successfully identified. In total 72.8% of the responses were properly identified (see Table 14). It should be noted that it is not implied that AtMP scores caused the outcomes.

Table 14
Modality and Temporal Contiguity Predicted by AtMP

	Modality [a]			Temporal Contiguity [b]		
Predictors	*B*	*SE B*	e^B	*B*	*SE B*	e^B
Constant	-0.30	0.17		0.86	0.18	
AtMP	0.08*	0.03	1.08	0.09*	0.03	1.09

Note [a] n = 158. R^2_L = .04, R^2_{CS} = .05, R^2_N = .06. Model χ^2 (1) = 7.81*.
[b] n = 162. R^2_L = .05, R^2_{CS} = .05, R^2_N = .08. Model χ^2 (1) = 8.82* *p < .01.

4.8. RQ7: Multivariate Logistic Regression

The final research question entailed four multivariate logistic regressions, which were meant to test if AtMP could predict the four CTML principles when controlled for the variables in RQ1-2. Similar to the results from the bivariate regressions the models for the multimedia and signaling principle were insignificant and the table was promptly expatriated to the appendices (see Appendix C-16). Furthermore, the signaling model failed to find a final solution, presumably due to complete separation caused by too many predictors compared to cases in the criterion variable (Tabachnick & Fidell, 2007, p. 442). By following the procedures from the preceding segment the two remaining models were found to be statistically significant. However, the AtMP scale was only significant in regards to the modality principle, and when controlled for the effect of the other predictors it had a negative impact on the students standpoint regarding the principle (B = -.11, p = .04). For each positive one-unit increase in AtMP the model predicted a 10% decrease in the odds ratio that the student would be in the yes-group (see Table 15 for a complete overview).

Table 15
Modality and Temporal Contiguity Controlled

	Modality [a]			Temporal Contiguity [b]		
Predictors	*B*	*SE B*	e^B	*B*	*SE B*	e^B
Constant	-2.92	0.98		-0.70	0.91	
AtMP	-0.11*	0.06	0.90	0.08	0.05	1.09
Gender by age						
Female (19-24) vs. Female (≥25)	-0.58	0.62	0.56	-0.19	0.73	0.83
Male (19-24) vs. Female (≥25)	-1.91*	0.78	0.15	-1.90*	0.86	0.15
Male (≥25) vs. Female (≥25)	-1.00	0.67	0.37	0.33	0.59	1.39
Lecturers’ Didactic Awareness	0.25	0.16	1.29	-0.31	0.18	0.74
Lecturers’ Media Literacy	0.28	0.24	1.32	0.53*	0.24	1.70
Students’ Media Literacy	0.31	0.21	1.36	-0.07	0.21	0.93
Grade Average						
≥D<C vs. ≥B<A	1.68*	0.87	5.36	-0.39	0.95	0.67
≥C<B vs. ≥B<A	0.74	0.65	2.10	0.74	0.85	2.09

Table 15

Modality and Temporal Contiguity Controlled

	Modality [a]			Temporal Contiguity [b]		
Predictors	*B*	*SE B*	e^B	*B*	*SE B*	e^B
Study programme						
Psychology vs. Medicine	1.56	0.91	4.77	2.47*	1.35	11.86
Dentistry vs. Medicine	2.55***	0.74	12.84	0.87	0.73	2.38
Education vs. Medicine	2.31*	0.93	10.05	0.90	1.00	2.47

Note [a] n = 151. R^2_{L} = .25, R^2_{CS} = .29, R^2_{N} = .39. Model χ^2 (12) = 51.98***.

[b] n = 155. R^2_{L} = .15, R^2_{CS} = .19, R^2_{N} = .28. Model χ^2 (12) = 27.92**.

*$p \leq .05$, **$p \leq .01$, ***$p \leq .001$.

5. Discussion

As the title of this thesis suggest, the term multimedia covers a large span, from the simplest IKEA manual to multifaceted and interactive 3D animations. Even with the research conducted by Mayer, Sweller and their colleagues, the learning outcome from the multimedia expanse is still mostly uncharted. The intent of this study has not been to measure objective learning outcome, but in line with the theoretical framework of CTML it is plausible that students' attitude toward multimodal presentations and traditional lectures may affect generative processing, and thereby meaningful learning as defined by Mayer. Through a synopsis of the data found in the preceding section, this concluding chapter aim to further describe these results within a CTML frame of reference.

5.1. A Medical Anomaly: Summary of Results

Though the regression models could explain approximately 50 per cent of the variance in the two scales, it still left another half unexplained or partly explained by the study programmes. There are many aspects not covered in this study, and the variance explained by the study programmes alone are more a continued mystery than a possible solution. The frequent use of PowerPoint as reported in this study, is consistent with findings by Norway Opening Universities (NOU), which is a national political initiative established and supported by the Norwegian government and the Ministry of Education and Research (Norway Opening Universities, 2011, p. 63). The results also indicated a strong negative relationship between AtMP and AtTL, meaning that positive attitudes toward one of the instructional mediums are largely identified by negative attitudes toward the other. On a sub-level of the scales (cf., Appendix C-5 and Appendix C-6), the results suggested structure and learning outcome was the greatest strength of multimodal presentations, while interaction between student and lecturer was the greatest benefit from traditional lectures. This seems to be in line with previous research (Hill, Arford, Lubitow, & Smollin, 2012; James, Burke, & Hutchins, 2006; Szabo & Hastings, 2000).

Furthermore, a majority of the students scored higher on the AtMP than the AtTL scale, that is, they reported generally more positive attitudes toward multimodal presentations than traditional lectures. This also conforms with NOU findings (2011, p. 113). A clear deviation from this assumption was found among the medicine graduates, which had a higher mean score of AtTL than the other study programmes reported for

AtMP. Although some studies (El Khoury & Mattar, 2012; Kahraman, Çevik, & Kodan, 2011) have given indications of possible differences between students' attitudes within hard and soft sciences, or quantitative and qualitative courses, it is not implied that medicine differs from the other study programmes on reasons of cultural or cognitive styles associated with paradigm affiliation (Muller, 2009). The reasons for the disparities between the study programmes are difficult to obtain, due to limitations with the methods and variables used, though nothing from the data indicates that traditional lectures are more used within medicine. It could be as simple as a preference for the instructional medium, or for lecturers who use traditional lectures, and as such it likely that attitudes toward the lecturers may have introduced conscious or unconscious bias toward multimodal presentations. Nonetheless, some of the results in this study may give a slight insight besides speculation.

5.1.1. Searching for AtMP. The descriptive results suggested that students' who perceived their lecturers intent to use multimodal presentations as retention driven, meaning the believed focus was to memorize the learning subject, had more negative attitudes toward such presentations than students who thought transference, or understanding, was a key element in the lectures. The most sceptical students was found among those who could not identify the intentions the lecturers had with their presentations, whereas the most positive was found among those who believed applying, analysing, evaluating or creating new understanding of the subject matter was the main focus of the instruction. This trend was apparent when the medicine students were removed from the equation, and since 76.7 per cent of the students from this group answered they did not know or they believed the intent was to remember the subject matter, it is reason to believe this may contribute to their attitudes. The results could also be seen as a parallel to CTML, indicating that certain students' do not perceive the applied presentations as adapted to foster meaningful learning (Moreno & Mayer, 2007).

Moreover, students who rated their own media literacies as low, that is, one or two on a scale from zero to six, scored a unit lower on the AtMP scale than students who rated themselves at three or higher. However, these students accounted for less than 15 per cent of the total sample, and the difference in AtMP score was not statistical significant. As one might expect, the picture was mirrored regarding the AtTL scale, where students with low self-reported media literacy stated they were mildly positive towards traditional lectures, whereas students with three or higher on the media literacy scale had a neutral AtTL score. Of the study programmes, almost a quarter of the medicine students (*n* = 14, 23.3%) constituted 58.3 per cent of the students within the group with low self-reported media literacy, and it is reasonable to have some impact, if minor, on their attitudes. The mean of the sample was between three and four for both genders in the two age groups. It should be noted the study only used a one-item scale to measure media literacy, and studies have shown students often report higher level of literacy than actual skills, which also varies across different literacies (Madigan, Goodfellow, & Stone, 2007; Official Norwegian Reports 2013:2).

Additionally, the results suggested that students related their lecturers' didactical awareness with lecturers' media literacy. Hence, a higher score on media literacy likely meant the student thought their lecturers were more aware of current research on how students' best learn from plenary lectures. The two items had no influence on students AtTL score when controlled for the effects from age and gender groups, study programmes and grade average from upper secondary education, but made a significant contribution to their AtMP score. The medicine students rated their lecturers lowest of the study programmes on both accounts. On the other hand, students from dentistry also reported somewhat low ratings on these items, but unlike the medicine students had a high mean score on the AtMP scale. A reason for this may be that 62.9 per cent of the dentistry students answered that understanding, applying, analysing, evaluating or creating new understanding of the subject matter was the main intent behind their lecturers' use of multimodal presentations. The psychology students were closest aligned with the prediction models, and scored highest on AtMP and rated their lecturers media literacy and didactic awareness highly relative to the other study programmes. Education had a large population of novice students, and at the time of the data collection 53.7 per cent of the students had only a month of experience from higher education. This could explain some of the inconsistencies within the study programme with several cases around the middle of the scales (i.e., neither or).

The students' assessment of their lecturers' didactic awareness also shared a negative relationship with accumulated credits from higher education. Meaning, the more credits earned from studying, the lower the score on didactic awareness. This may indicate that, (a) novice students have less experience and in-depth knowledge of their field and are therefore less able to assess their lectures; (b) lecturers' didactical knowledge are more acutely aligned with the needs of low-knowledge students and use the same methods regardless of knowledge level among the students (Kirschner, Sweller, & Clark, 2006). The latter share characteristics with Kalyuga's (2007, p. 26) definition of expertise reversal effect as "imbalances between learner organized knowledge base and provided instructional guidance". As there is a close relationship between attitudes, motivation and germane cognitive load, one need to poise teaching methods with the learners intrinsic goals in order to foster meaningful learning (Kalyuga, 2007; Mayer, 2011b).

Furthermore, though the medicine graduates clearly favoured traditional lectures, 54.2 per cent of these students believed complex multimodal presentations would be best for their learning outcome, and on this point there was no statistically difference between the study programmes. This may indicate that a part of the negative attitudes toward multimodal presentations was not against the instructional medium itself, but rather towards methods and content used. The same pattern was found among the differences between genders across the two age groups. The multiple regression conducted signified that only older males were statistically different from the other age and gender groups by scoring less on AtMP and higher on AtTL. Older males were overrepresented (n = 25, 73.5%) in the retention and not knowing groups, and also within wanting complex multimedia presentations (n = 22, 62.9%), which further strengthen the notion that perceived teaching intentions and preferred presentation format play a significant part in students attitudes. When controlled for the other variables, grade average from upper secondary school gave the same indications, which is not surprising regarding the close relationship between grades study programmes and credits from higher education (cf., Table 1).

5.1.2. Perceptions of Multimedia Principles. The descriptive statistics clearly indicated that the students, independent of study programmes, were either positive or neutral toward the CTML principles, and a clear majority agreed that the multimedia and signalling principle benefitted their learning. As mentioned in section 3.4.4.4 the four statements were recoded into a binary variable allowing only yes or no alternatives, thus, a neutral response would entail that the principle did not foster deeper learning. According to the biserial correlation conducted between the four CTML principles and AtMP, there was a positive relationship between them, but only the modality principle and temporal contiguity principle were statistically significant. Hence, the results indicated that positive attitudes towards multimodal presentations would increase the likelihood of supporting the principles. The binary logistic regressions revealed that younger males (19-24 years) were most reluctant to answer yes when controlled for the other predictors, and descriptive results suggested that these were more inclined to answer *neither or* to all the four statements relative to the other age and gender groups. Younger males had also a consistently high AtMP score, and consequently AtMP had a small negative effect on the students' response to the modality principle. Since 68.4 per cent (n = 13) of the younger males were freshmen, with a month of experience from higher education, the moderate responses seems reasonable.

Medicine students (n = 51, 85%) contributed with 58 per cent of the population in the no-group regarding the modality principle, and a reasonable explanation for this overrepresentation could be found in Mayer's (2009) notion of boundary condition. Mayer (2009, p. 212) states "an important boundary condition for the modality effect is that the modality effect applies most strongly when the materials require building a mental model rather than simply memorizing isolated elements". The results from the study have suggested that a large portion of the medicine students in particular perceived the use of multimodal presentation as an exercise in remembering the subject matter. Additionally, the modality effect weakens when instruction involves technical terms and symbols, both commonly associated with medical education (Mayer, 2009). Consequently, the modality principle may have less effect on the students from this study programme.

Contrary to the modality principle, the temporal continuity principle still had a majority of students answering yes to the statement after the item was recoded. Accordingly there were fewer differences between the study programmes. Nonetheless, the medicine graduates still constituted 53.2 per cent (n = 25 = 41.7%) of the students within the no-group, but were significantly different only to the psychology students. Also, the likelihood of a student answering yes to the statement was enhanced by higher ratings of their lecturers' media literacy. Hence, a reasonable interpretation could be that psychology students, who generally rate their lecturers' media literacy as high and score highest on AtMP, have lecturers who design multimodal presentation in a way which emphasises the benefit of presenting corresponding pictures and words simultaneously. Another conceivable interpretation involves boundary conditions within the principle itself. Mayer (2009, p. 166) claims successive small-segmented presentations, even if the subject matter is highly interconnected equals the effect from the temporal contiguity principle when presentations involve long continuous segments. This interpretation is more in line with the reasoning for the modality principle as presented above, and may explain some of the medicine students' perceptions. Even so, less than 40 per cent of the variance in student perceptions could be explained by the logistic regression models, and it is clear that there are many unanswered questions.

The study measured students' subjective assessment of their own learning outcome, thus, it may or may not reflect their actual dividends or the actual usage of multimodal presentations (Sung & Mayer, 2012; Tangen et al., 2011). Objective learning outcome and usage is among the questions left unanswered, and the ensuing section provides some closing considerations regarding current constraints and future directions.

5.2. Limitations, Future Research and Final Thoughts

The presented study is based on individual student responses and is bound by the empirical constraints associated with self-reporting measures (Barker, Pistrang, Elliott, & Barker, 2002, p. 95). The overall framework of the study made it unobtainable to observe the actual usage of multimodal presentations and assess whether there were differences in methods and multimedia design between the four study programmes. Moreover, the lack of a lecturer perspective, and preferably an additional in-depth qualitative approach (e.g., focus groups), entails that this is a rather unidimensional study. The most severe limitation with the study is nevertheless the sampling procedure and the obviously skewed attributes among the students and study programmes. One might argue that the students from education and psychology and those from medicine and dentistry come from two different populations due to the large gap between novice and advanced students, and the researcher is inclined to agree with this argument. Though the thesis operates with the term study programme to differentiate between the disciplines, it would probably be more accurate to describe them as different classes, as it is tendentious to claim that the students from these classes are representative of students from their respective field. This as a consequence of the convenience sampling used. Furthermore, the sample size is small when comparing four different groups and the results should be interpreted accordingly.

In summary, the study suggested that generic use of multimodal presentations are not appreciated by all students, especially older males and experienced students.

Still, the results also indicated that there is a want for more complex multimodal presentations, regardless of attitudes toward the instructional medium. Thus, borrowing the wording of Doumont (2005), it gives food for thought that negative attitudes reflect more the product and less the production tool. This notion leads to two main implications for future research. Firstly, though there is a dearth of empirical research on students' perception on the benefits of instructional mediums, there is even less research on lecturers' methods and actual usage of such mediums. Secondly, if students desire complex multimodal presentations, there is a need to uncover to what extent these benefits their objective learning outcome and not just their interest and motivation. Both of these assumptions demands lecturers that are highly media literate. Although combining various mediums may not need a proficiency level beyond basic computer and specific software skills, CTML states that redundant information, whether it is words or pictures, may weaken or even reverse meaningful learning. It stands to reason that combining more mediums equals a greater risk of adding redundant information.

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Appendices

Appendix A Approval from the Norwegian Social Science Data Services (NSD)

Norsk samfunnsvitenskapelig datatjeneste AS
NORWEGIAN SOCIAL SCIENCE DATA SERVICES

Harald Hårfagres gate 29
N-5007 Bergen
Norway
Tel: +47-55 58 21 17
Fax: +47-55 58 96 50
nsd@nsd.uib.no
www.nsd.uib.no
Org.nr. 985 321 884

Rune Johan Krumsvik
Institutt for pedagogikk
Universitetet i Bergen
Christies gate 13
5020 BERGEN

Vår dato: 05.07.2012 Vår ref:30930 / 3 / LMR Deres dato: Deres ref:

TILBAKEMELDING PÅ MELDING OM BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 26.06.2012. Meldingen gjelder prosjektet:

30930	*Ein digital kvardag: om studentar sine haldningar til multimodale presentasjonsprogram og tradisjonell tavleundervising*
Behandlingsansvarlig	*Universitetet i Bergen, ved institusjonens øverste leder*
Daglig ansvarlig	*Rune Johan Krumsvik*
Student	*Øystein Olav Skaar*

Etter gjennomgang av opplysninger gitt i meldeskjemaet og øvrig dokumentasjon, finner vi at prosjektet ikke medfører meldeplikt eller konsesjonsplikt etter personopplysningslovens §§ 31 og 33.

Dersom prosjektopplegget endres i forhold til de opplysninger som ligger til grunn for vår vurdering, skal prosjektet meldes på nytt. Endringsmeldinger gis via et eget skjema, http://www.nsd.uib.no/personvern/forsk_stud/skjema.html.

Vedlagt følger vår begrunnelse for hvorfor prosjektet ikke er meldepliktig.

Vennlig hilsen

Knut Kalgraff Skjåk

Linn-Merethe Rød

Kontaktperson: Linn-Merethe Rød tlf: 55 58 89 11
Vedlegg: Prosjektvurdering
Kopi: Øystein Olav Skaar, Olaf Ryes Vei 23 B, 5007 BERGEN

Personvernombudet for forskning

Prosjektvurdering - Kommentar

Prosjektnr: 30930

Utvalget består av studenter. Data samles inn via mentormeterknapp-system benyttet ved forelesninger. Ombudet forstår ut ifra meldeskjema at mentormeterkapp-systemet ikke er knyttet opp mot studentenes navn, studentnummer, e-postadresse eller lignende, og at det heller ikke registreres tilstrekkelig med demografiske data til at enkeltpersoner kan identifiseres indirekte. Det anbefales imidlertid at aldersvariabelen grovkategoriseres ved datainnsamling.

Personvernombudet finner på denne bakgrunn at studien ikke er omfattet av meldeplikt.

Ombudet minner om at anonyme opplysninger er opplysninger som det ikke er mulig å føre tilbake til enkeltpersoner verken direkte (via navn eller fødselsnummer eller referanse til slike opplysninger, f.eks. via et løpenummer som viser til navn på en navneliste) eller indirekte (via sammenstilling av bakgrunnsopplysninger som f.eks. navn på bosted og/eller kommune og/eller studiested, sammen med alder og kjønn eller yrke eller referanse til slike opplysninger).

Appendix B Questionnaire

Del I – Demografisk data om informanten

1. Er du kvinne eller mann?

☐ Kvinne

☐ Mann

2. Hva er din alder?

☐ 19-24 år

☐ 25-29 år

☐ 30-32 år

☐ 33 år eller eldre

3. Hva er karaktergjennomsnittet ditt fra videregående skole?

☐ 2 eller over, men under 3

☐ 3 eller over, men under 4

☐ 4 eller over, men under 5

☐ 5 eller over, men under 6

☐ 6

4. Hvor mange studiepoeng har du fra høyere utdanning?

☐ 0

☐ 1-59

☐ 60-119

☐ 120-179

☐ 180-239

☐ 240-299

☐ 300 studiepoeng eller mer

5. Hva er din fars høyeste utdannelse?

☐ Grunnskole

☐ Fullført studieforberedende utdannelse (allmennfag, videregående skole)

☐ Fullført yrkesrettet utdannelse

☐ Utdanning på mellomnivå (inntil to år høyere utdanning)

☐ Kortere høyere utdannelse (inntil fire år)

☐ Lengre høyere utdannelse (fem år eller mer)

6. Hva er din mors høyeste utdannelse?

☐ Grunnskole

☐ Fullført studieforberedende utdannelse (allmennfag, videregående skole)

☐ Fullført yrkesrettet utdannelse

☐ Utdanning på mellomnivå (inntil to år høyere utdanning)

☐ Kortere høyere utdannelse (inntil fire år)

☐ Lengre høyere utdannelse (fem år eller mer)

7. Er det viktig for deg å gjøre det bra i utdanningen?

☐ Ja

☐ Til en viss grad

☐ Nei

Del II – Kartlegging av dataferdigheter og bruk av undervisningsverktøy

Begrepsavklaring

Med **PowerPoint** menes presentasjonsverktøy som gjør det mulig å kombinere bruk av skriftlige ord (tekst), munnlig ord (tale, lyd), bilder (illustrasjoner, foto), animasjoner og video.
Tradisjonell tavleundervisning: Undervisning hvor foreleser bruker tavle og kritt.
Med **dataferdigheter** menes den generelle evne til å bruke PC/Mac, standardverktøy (for eksempel tekstbehandling, presentasjonsverktøy) og digitale læremiddel (for eksempel digitale læremiddel i utdanningen).
Med **forelesning** i denne undersøkelsen menes undervisning som har en forelesningsstil som foregår i store studentgrupper (30→) og hvor dette er lokalisert til store klasserom/auditorium.

8. Hadde du tilbud om skole-pc (egen bærbar pc) da du gikk i videregående skole?

☐ Ja

☐ Nei

9. Hvordan vil du vurdere dataferdighetene dine?

☐ 0 (ingen ferdigheter)

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6 (høye ferdigheter)

10. Hvordan vil du vurdere dataferdighetene til foreleserne dine på studiet ditt?

☐ 0 (ingen ferdigheter)

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6 (høye ferdigheter)

11. Forelesere på mitt studium er oppdatert på forskningen om hvordan studenter lærer best fra en forelesning:

☐ Helt enig

☐ Svært enig

☐ Litt enig

☐ Verken eller

☐ Litt uenig

☐ Svært uenig

☐ Helt uenig

12. Jeg foretrekker forelesninger som er mest preget av:

☐ Monolog fra foreleser

☐ Kombinasjon av monolog og dialog

☐ Kombinasjon av monolog, dialog og «summing» (diskusjon to og to sammen)

☐ Kombinasjon av monolog, dialog, «summing» og «case»-analyse (studenter analyserer autentiske caser)

☐ Andre

☐ Vet ikke

13. Når forelesere bruker PowerPoint på studiet mitt oppfatter jeg at intensjonen oftest er at:

☐ Vi skal huske fagstoffet (f.eks. huske definisjoner)

☐ Vi skal forstå fagstoffet (f.eks. fortolke det)

☐ Vi skal kunne anvende fagstoffet (f.eks. til å løse problemstillinger)

☐ Vi skal kunne analysere fagstoffet (f.eks. dele det opp, se sammenhenger)

☐ Vi skal kunne evaluere fagstoffet (f.eks. vurdere metodebruk kritisk)

☐ Vi skal kunne skape ny forståelse basert på fagstoffet (f.eks skape nye produkt)

☐ Vet ikke

14. Hvilke undervisingsverktøy blir mest brukt under forelesninger på studiet ditt?

☐ PowerPoint

☐ Tradisjonell tavleundervisning

☐ PowerPoint og tradisjonell tavleundervising, der en bruker mest tid på tradisjonell tavleundervising

☐ PowerPoint og tradisjonell tavleundervising, der en bruker mest tid på PowerPoint

☐ Annet

15. Når PowerPoint blir brukt av forelesere på studiet ditt – hva blir den mest brukt til?

☐ Presentasjon med skriftlige ord (tekst)

☐ Presentasjon av skriftlige ord (tekst) og munnlige ord (tale, lyd)

☐ Presentasjon av skriftlige ord (tekst), munnlige ord (tale, lyd) og bilder (illustrasjoner, foto)

☐ Presentasjon av skriflige ord (tekst), munnlige ord (tale, lyd), bilder (illustrasjoner, foto) og animasjoner

☐ Presentasjon av skriflige ord (tekst), munnlige ord (tale, lyd), bilder (illustrasjoner, foto), animasjoner og video

☐ Vet ikke

16. Når PowerPoint blir brukt på studiet ditt – hvilken presentasjonsform har du best læringsutbytte fra?

☐ Presentasjon med skriftlige ord (tekst)

☐ Presentasjon av skriftlige ord (tekst) og munnlige ord (tale, lyd)

☐ Presentasjon av skriftlige ord (tekst), munnlige ord (tale, lyd) og bilder (illustrasjoner, foto)

☐Presentasjon av skriflige ord (tekst), munnlige ord (tale, lyd), bilder (illustrasjoner, foto) og animasjoner

☐Presentasjon av skriflige ord (tekst), munnlige ord (tale, lyd), bilder (illustrasjoner, foto), animasjoner og video

☐ Vet ikke

17. Når foreleser bruker PowerPoint har jeg bedre læringsutbytte fra tekst og bilder enn fra tekst alene:

☐ Helt enig

☐ Svært enig

☐ Litt enig

☐ Verken eller

☐ Litt uenig

☐ Svært uenig

☐ Helt uenig

18. Når foreleser bruker PowerPoint har jeg <u>bedre</u> læringsutbytte fra tale og bilder (samtidig) enn fra tekst og bilder (samtidig):

☐ Helt enig

☐ Svært enig

☐ Litt enig

☐ Verken eller

☐ Litt uenig

☐ Svært uenig

☐ Helt uenig

19. Når foreleser bruker PowerPoint har jeg <u>bedre</u> læringsutbytte når ord og bilder med innbyrdes relevans presenteres samtidig enn suksessivt:

☐ Helt enig

☐ Svært enig

☐ Litt enig

☐ Verken eller

☐ Litt uenig

☐ Svært uenig

☐ Helt uenig

20. Når foreleser bruker PowerPoint har jeg <u>bedre</u> lærings-utbytte hvis den vesentligste informasjonen fremheves /utheves blant øvrig informasjon i PowerPoint-presentasjonen:

☐ Helt enig

☐ Svært enig

☐ Litt enig

☐ Verken eller

☐ Litt uenig

☐ Svært uenig

☐ Helt uenig

21. Blir PowerPoint-presentasjoner gjort tilgjengelig i forkant av forelesningen på studiet ditt?

☐ Alltid

☐ Svært ofte

☐ Ofte

☐ Sjelden

☐ Svært sjelden

☐ Aldri

22. Jeg blir <u>mer</u> motivert til å møte til forelesningen dersom foreleser legger ut PowerPoint-presentasjoner i forkant av forelesningen

☐ Helt enig

☐ Svært enig

☐ Litt enig

☐ Verken eller

☐ Litt uenig

☐ Svært uenig

☐ Helt uenig

23. Bruker du forelesers PowerPoint-presentasjoner som en del av egenstudier, i forkant og/eller i etterkant av forelesninger?

☐ Alltid

☐ Svært ofte

☐ Ofte

☐ Sjelden

☐ Svært sjelden

☐ Aldri

Del III – Kartlegging av AtMP og AtTL

24. Jeg synes forelesninger blir bedre strukturert når det brukes PowerPoint:

☐ Helt enig

☐ Svært enig

☐ Litt enig

☐ Verken eller

☐ Litt uenig

☐ Svært uenig

☐ Helt uenig

25. Jeg synes forelesninger blir bedre strukturert når det brukes tradisjonell tavleundervisning:

☐ Helt enig

☐ Svært enig

☐ Litt enig

☐ Verken eller

☐ Litt uenig

☐ Svært uenig

☐ Helt uenig

26. Jeg har mindre læringsutbytte fra forelesninger hvor PowerPoint blir brukt:

☐ Helt enig

☐ Svært enig

☐ Litt enig

☐ Verken eller

☐ Litt uenig

☐ Svært uenig

☐ Helt uenig

27. Jeg har <u>mindre</u> læringsutbytte fra forelesninger hvor det bare er tradisjonell tavleundervisning:

☐ Helt enig

☐ Svært enig

☐ Litt enig

☐ Verken eller

☐ Litt uenig

☐ Svært uenig

☐ Helt uenig

28. Jeg blir <u>mer</u> motivert til å møte på forelesning når det brukes PowerPoint:

☐ Helt enig

☐ Svært enig

☐ Litt enig

☐ Verken eller

☐ Litt uenig

☐ Svært uenig

☐ Helt uenig

29. Jeg blir <u>mer</u> motivert til å møte på forelesning når det brukes tradisjonell tavleundervisning:

☐ Helt enig

☐ Svært enig

☐ Litt enig

☐ Verken eller

☐ Litt uenig

☐ Svært uenig

☐ Helt uenig

30. Det er mer interaktivitet mellom foreleser og studenter når det brukes PowerPoint:

☐ Helt enig

☐ Svært enig

☐ Litt enig

☐ Verken eller

☐ Litt uenig

☐ Svært uenig

☐ Helt uenig

31. Det er mer interaktivitet mellom foreleser og studenter når det brukes tavleundervisning:

☐ Helt enig

☐ Svært enig

☐ Litt enig

☐ Verken eller

☐ Litt uenig

☐ Svært uenig

☐ Helt uenig

Appendix B-1 *Questionnaire - From Draft to Final Version*

Source	File type	Version
http://db.tt/5o0qzaUL	docx	Draft
http://db.tt/ha1ULeA4	pptx	Rev 1
http://db.tt/NlVWNUou	pptx	Rev 2
http://db.tt/2i8rIDNs	pptx	Rev 3
http://db.tt/fkSXwjH2	html	Rev 3 – Pilot
http://db.tt/7zYvJ40R	pptx	Final

Appendix C Tables and Figures

Appendix C-1 *Literature Review Procedure*

Subject	Included	Excluded
Theme	Students' perceived learning outcome from, and attitudes toward instructional mediums in plenary lectures. Cognitive Theory of Multimedia Learning Cognitive Load Theory	Instruction involving Learning Management Systems (LMS) and web-based environments.
Literature	Articles, reviews and meta-analyses, both qualitative and quantitative	Non-peer reviewed articles Literature prior to 2009
Databases	JSTOR, ScienceDirect, ERIC and Google Scholar	-
Keywords	Combinations of digital literacy, digital competence, digital divide, student perceptions or student attitudes with educational technology, chalk and talk, blackboard or PowerPoint Cognitive Theory of Multimedia Learning Cognitive Load Theory	LMS, online community, online environment, distance education, online formative assessment and web 2.0

Appendix C-2 *Item Non-response Rate*

Number of missing items	Total		Psychology		Dentistry		Education		Medicine	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
0	128	75.7	13	56.5	26	96.3	37	64.9	52	83.9
1	29	17.2	5	21.7	1	3.7	17	29.8	6	9.7
2	7	3.6	4	17.4	-	-	-	-	2	3.2
3	3	1.8	-	-	-	-	2	3.5	1	1.6
7	1	.6	-	-	-	-	1	1.8	-	-
8	1	.6	1	4.3	-	-	-	-	-	-
25	1	.6	-	-	-	-	-	-	1	1.6

Appendix C-3 *AtMP and AtTL Sub-items Correlations*

Scale	1	2	3	4
AtMP[a]				
1. Structure	-	.724	.686	.622
2. Learning Outcome		-	.612	.599
3. Motivation			-	.524
4. Interaction				-
AtTL[b]				
1. Structure	-	.640	.698	.636
2. Learning Outcome		-	.701	.609
3. Motivation			-	.732
4. Interaction				-

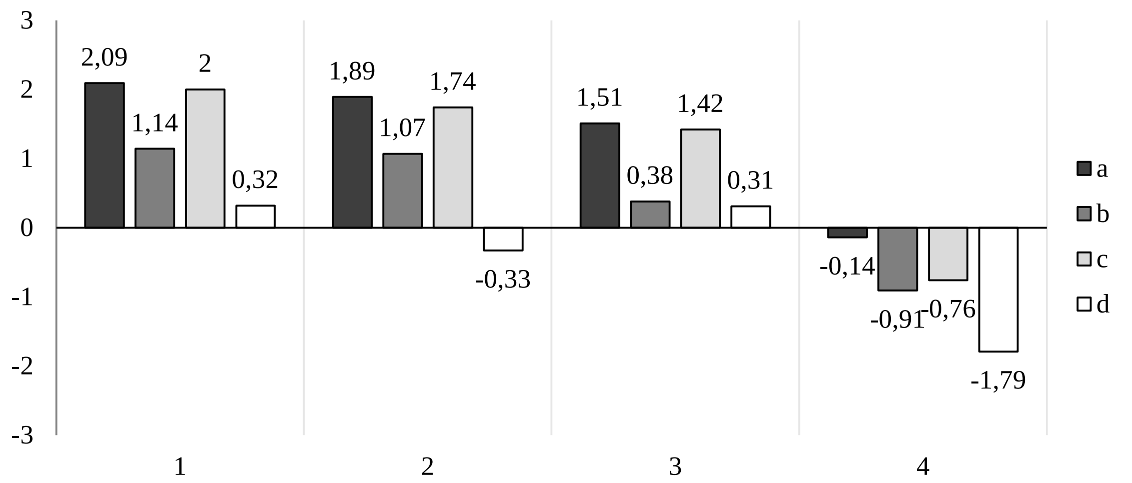
Note. [a] $n = 162$. [b] $n = 158$. $p < .001$.

Appendix C-4 *AtMP and AtTL correlation*

Scale	Total		Psychology		Dentistry		Education		Medicine	
	n	r	n	r_s	n	r_s	n	r_s	n	r_s
AtMP – AtTL	162	-.81**	19	-.51*	27	-.64**	53	-.63**	56	-.61*

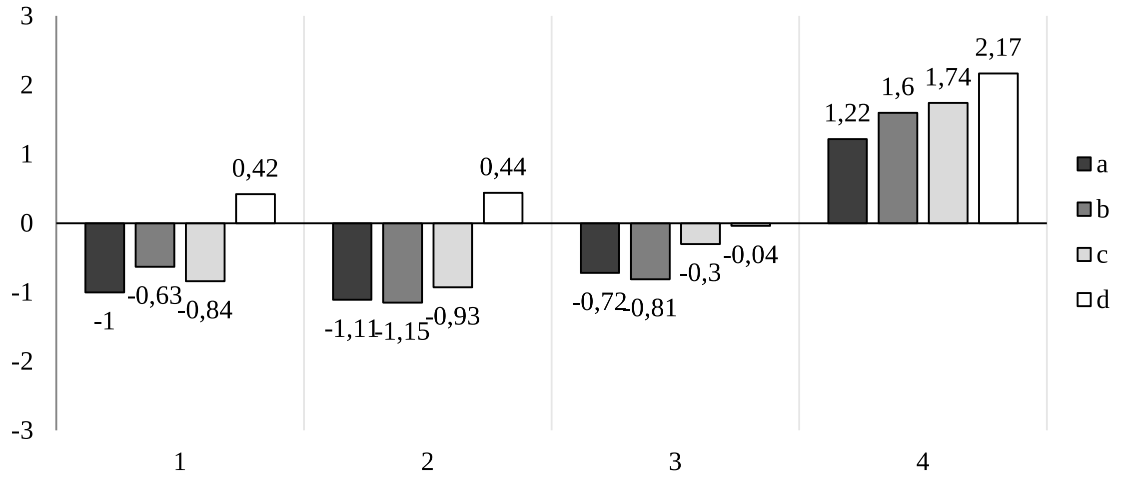
Note. * $p \leq .05$ level (1-tailed). ** $p \leq .001$ level (1-tailed).

Appendix C-5 *AtMP Sub-items by Study Programme*



Note. [a] Structure. [b] Motivation. [c] Learning Outcome [d] Interaction.
(1) Psychology (n = 22). (2) Dentistry (n = 27). (3) Education (n = 55). (4) Medicine (n = 58).

Appendix C-6 *AtTL Sub-items by Study Programme*



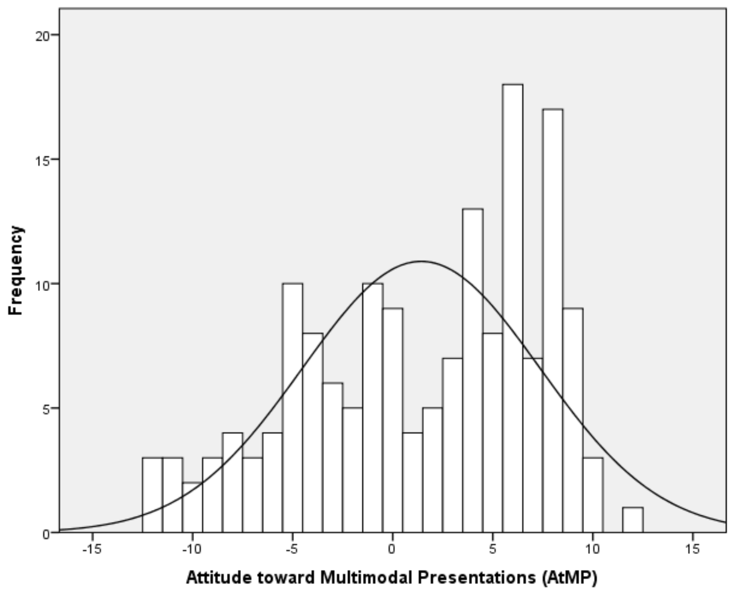
Note. [a] Structure. [b] Motivation. [c] Learning Outcome [d] Interaction.
(1) Psychology (*n* = 19).(2) Dentistry (*n* = 27). (3) Education (*n* = 54). (4) Medicine (*n* = 58).

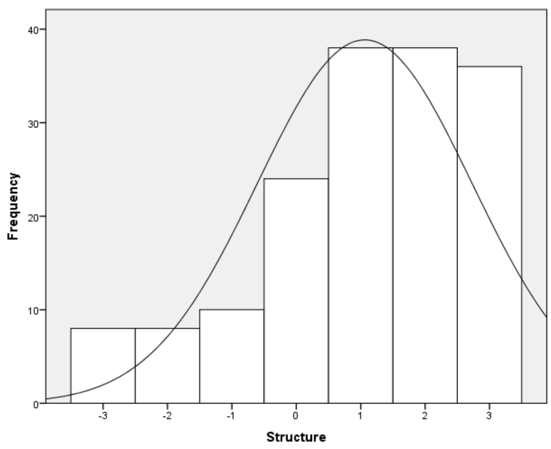
Appendix C-7 *AtMP and AtTL Descriptive Statistics*

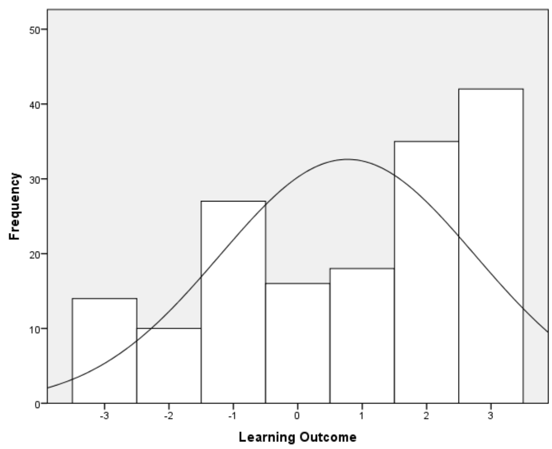
Type	Scale	*n*	*M*	*SE*	*SD*	*Sk*	*SES*	*z*	*Ku*	*SEK*	*z*
1	**AtMP**	**162**	**1.42**	**.466**	**5.933**	**-.468**	**.191**	**2.450**	**-.814**	**.379**	**2.148**
	Structure	162	1.06	.131	1.663	-.804	.191	4.209	.001	.379	.003
	Learning	162	.77	.156	1.982	-.478	.191	2.503	-1.048	.379	2.765
	Motivation	162	.14	.135	1.714	-.334	.191	1.749	-.606	.379	1.599
	Interaction	162	-.55	.127	1.619	-.066	.191	.345	-.905	.379	2.388
	AtTL	**158**	**1.12**	**.491**	**6.177**	**.077**	**.193**	**.399**	**-.925**	**.384**	**2.409**
	Structure	158	-.11	.144	1.804	.070	.193	.363	-.885	.384	2.305
	Learning	158	.28	.154	1.935	-.091	.193	.472	-1.162	.384	3.026
	Motivation	158	.04	.145	1.820	-.076	.193	.394	-.878	.384	2.287
	Interaction	158	.91	.124	1.561	-.370	.193	1.917	-.292	.384	.750
2	AtMP	22	5.55	.800	3.751	-.924	.491	1.882	1.063	.953	1.115
	AtTL	19	-2.05	.800	3.488	.049	.524	.094	-.259	1.014	.255
3	AtMP	27	4.37	1.004	5.219	-1.397	.448	3.118	2.237	.872	2.565
	AtTL	27	-2.74	1.034	5.375	.759	.448	1.694	.439	.872	.053
4	AtMP	55	3.62	.609	4.515	-1.354	.322	4.205	1.724	.634	2.719
	AtTL	54	-1.87	.652	4.790	.396	.325	1.218	.616	.639	.964
5	AtMP	58	-3.60	.609	4.634	.447	.314	1.424	.190	.618	.307
	AtTL	58	6.74	.652	3.963	-.688	.314	2.191	.081	.618	.131

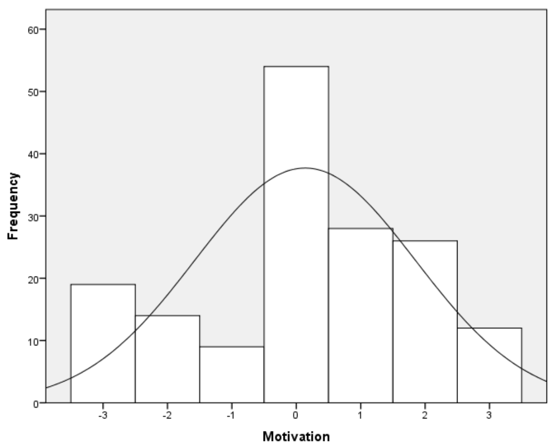
Note. (1) Total. (2) Psychology. (3) Dentistry. (4) Education. (5) Medicine.

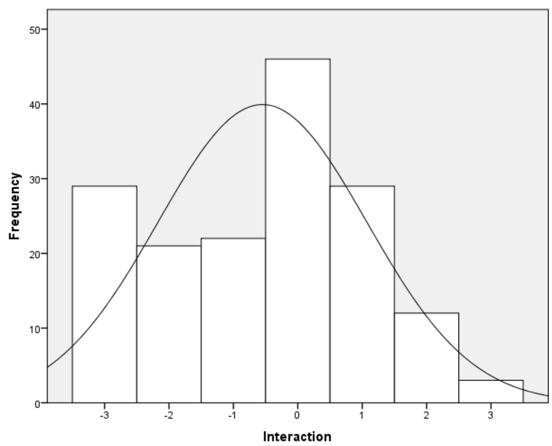
Appendix C-8 *AtMP and AtTL Histograms*



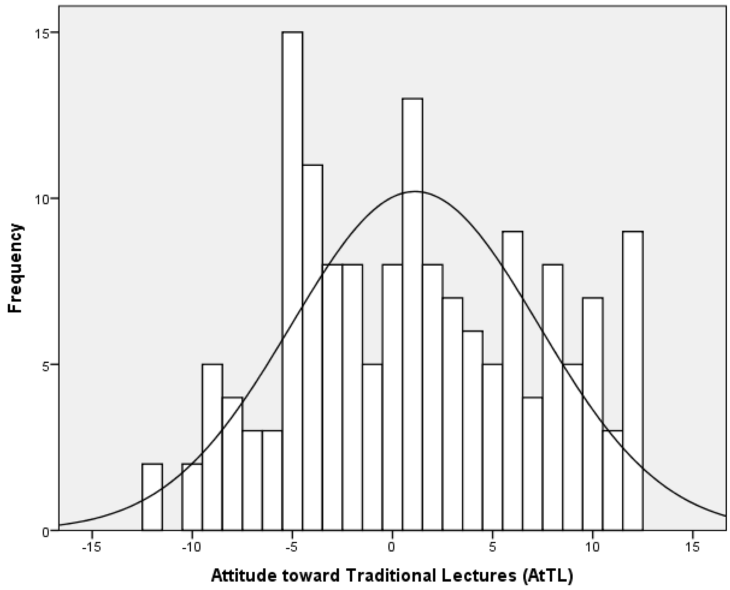


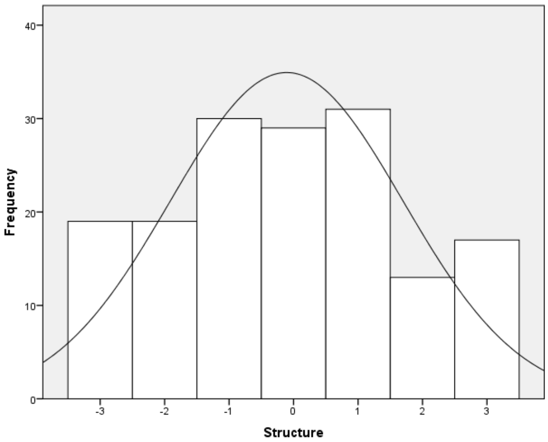


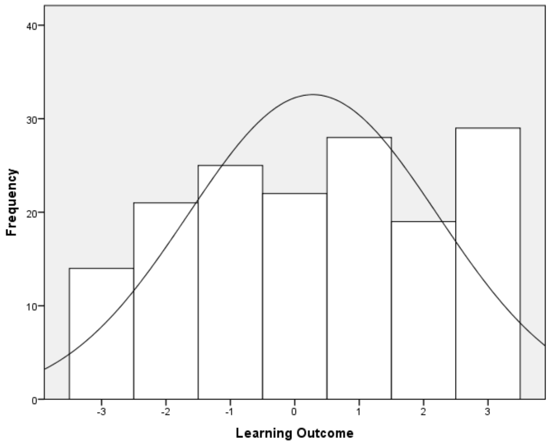


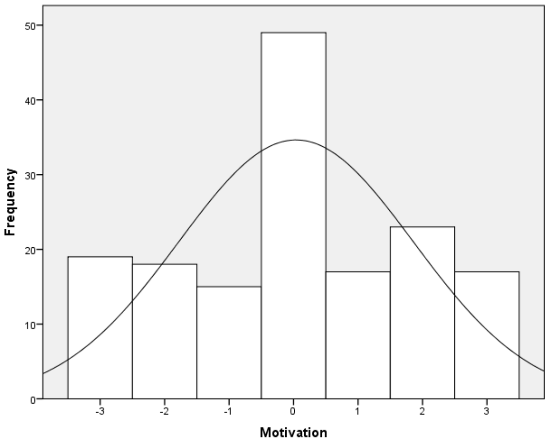


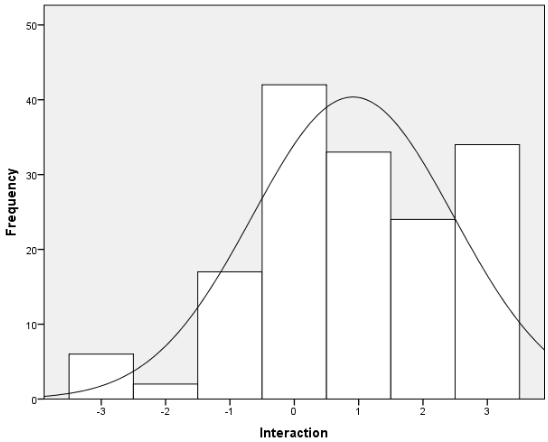
Appendix C-8 *AtMP and AtTL Histograms*











Appendix C-9 *Media Literacy and Didactic Awareness Descriptive Statistics*

Institution	Scale	*n*	*M*	*SE*	*SD*	*Sk*	*SES*	*z*	*Ku*	*SEK*	*z*
Total											
	1	165	3.50	.080	1.022	.044	.189	.233	.142	.376	.378
	2	162	2.41	.078	.994	.145	.191	.759	-.216	.379	-.570
	3	164	-.59	.127	1.628	.103	.190	.542	-1.152	.377	-3.056
Psychology											
	1	22	3.68	.222	1.041	-.397	.491	-.809	1.698	.953	1.782
	2	21	3.24	.168	.768	-.453	.501	-.904	-1.095	.972	-1.127
	3	22	.50	.307	1.439	-.474	.491	-.965	-.639	.953	-.671
Dentistry											
	1	27	3.68	.192	1.000	.748	.488	1.533	.658	.872	.755
	2	27	2.26	.189	.984	.215	.448	.480	1.557	.872	1.786
	3	27	-.96	.247	1.285	.513	.448	1.145	-.349	.872	-.400
Education											
	1	56	3.50	.132	.991	-.116	.319	-.364	.521	.628	.830
	2	55	2.60	.131	.974	.145	.322	.450	.062	.634	.098
	3	55	.58	.129	.956	-.242	.322	-.752	.366	.634	.577
Medicine											
	1	60	3.37	.136	1.057	.097	.309	.314	-.482	.608	-.793
	2	59	2.00	.113	.871	.324	.311	1.042	-.105	.613	-.171
	3	60	-1.88	.160	1.236	1.720	.309	5.566	3.275	.608	5.387

Note. 1) Students' media literacy; 2) Lecturers' media literacy; 3) Lecturers' didactical awareness

Appendix C-10 *Preferred Lecture Format and Use of Multimodal Presentations*

Item	Type	*n*	%
Instructional Medium			
Which instructional medium is most frequently used during lectures in your study programme?	PowerPoint	121	73.3
	PowerPoint and Traditional Lectures with most time spent on the latter	2	1.2
	PowerPoint and Traditional Lectures with most time spent on the former	39	23.6
	Other	1	0.6
	Missing	2	1.2
	Total	165	100
Preferred Lecture Format			
I prefer lectures that are characterized by	Monologue	17	10.3
	Mixture of monologue and dialogue	46	27.9
	Mixture of monologue, dialogue and discussion with fellow student.	37	22.4

	Mixture of monologue, dialogue, discussion with fellow student and case study.	57	34.5
	Other	4	2.4
	Don't know	2	1.2
	Missing	2	1.2
	Total	165	100
Perceived intent of Multimodal Presentations			
When PowerPoint is used by lecturers in your study programme, what intentions do you think they have? [that we should]	Remember the subject matter *(e.g., remember definitions)*	47	28.7
	Understand the subject matter *(e.g., interpret it)*	49	29.7
	Be able to apply the subject matter *(e.g., to solve problems)*	17	10.3
	Analyse the subject matter *(e.g., see connections)*	11	6.7
	Be able to evaluate the subject matter *(e.g., review methods)*	-	-
	Be able to create new understandings based on the subject matter *(e.g., creating new products)*	2	1.2
	Don't know	37	22.4
	Missing	2	1.2
	Total	165	100
Use of Multimodal Presentations			
When PowerPoint is used by lecturers in your study programme, what is the most common usage?	Written text.	54	32.7
	Written text and oral text	10	6.1
	Written text, oral text and graphics	76	46.1
	Written text, oral text, graphics and animations	5	3.0
	Written text, oral text, graphics, animations and video	10	6.1
	Don't know	7	4.2
	Missing	3	1.8
	Total	165	100
Learning from Multimodal Presentation			
When PowerPoint is used by lecturers in your study programme, which presentation form is best for your learning outcome?	Written text.	19	11.5
	Written text and oral text	8	4.8
	Written text, oral text and graphics	36	21.8
	Written text, oral text, graphics and animations	17	10.3
	Written text, oral text, graphics, animations and video	71	43.0
	Don't know	12	7.3
	Missing	2	1.2
	Total	165	100

Appendix C-11 *The Multimedia Principles*

Item	Type		n	%
Multimedia Principle				
When PowerPoint is used by lecturer I learn better from words and graphics than from words alone	Completely agree		65	39.9
	Strongly agree		36	21.8
	Slightly agree		34	20.9
	Neither or		17	10.4
	Slightly disagree		7	4.3
	Strongly disagree		2	1.2
	Completely disagree		2	1.2
		Missing	2	1.2
		Total	165	100
Modality Principle				
When PowerPoint is used by lecturer I learn better from oral text and graphics (simultaneously) than from written text and graphics (simultaneously)	Completely agree		26	15.8
	Strongly agree		20	12.1
	Slightly agree		27	16.4
	Neither or		50	30.3
	Slightly disagree		17	10.3
	Strongly disagree		10	6.1
	Completely disagree		11	6.7
		Missing	4	2.4
		Total	165	100
Temporal Contiguity Principle				
I learn better when corresponding words and graphics are presented simultaneously rather than successively	Completely agree		35	21.2
	Strongly agree		47	28.5
	Slightly agree		36	21.8
	Neither or		31	18.8
	Slightly disagree		12	7.3
	Strongly disagree		2	1.2
	Completely disagree		2	1.2
		Missing	-	-
		Total	165	100
Signaling Principle				
I learn better when cues that highlight the organization of the essential material are added	Completely agree		104	63.0
	Strongly agree		39	23.6
	Slightly agree		13	7.9
	Neither or		4	2.4
	Slightly disagree		2	1.2
		Missing	3	1.8
		Total	165	100

Appendix C-12 *Perceived Intent of Multimodal Presentations (2)*

Type	Total		Psychology		Dentistry		Education		Medicine	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Remember the subject matter	47	28.5	4	1.2	6	22.2	13	23.6	24	40
Understand the subject matter	49	29.7	11	40.4	9	33.3	21	37.5	8	13.3
Don't know	37	22.4	2	9.1	4	14.8	9	16.1	22	36.7
Other	30	18.2	4	18.2	8	29.6	12	21.4	6	10
Missing	2	1.2	1	4.5	-	-	1	1.8	-	-
Total	165	100	22	100	17	100	55	100	60	100

Appendix C-13 *Perceived use of Multimodal Presentations (2)*

Type	Total		Psychology		Dentistry		Education		Medicine	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Multimodal (basic)	64	38.8	8	36.4	9	33.3	26	46.4	21	35
Basic Multimodal	76	46.1	8	36.4	18	66.7	21	37.5	29	48.3
Complex Multimodal	15	9.1	5	22.7	-	-	6	10.7	4	6.7
Don't know	7	4.2	-	-	-	-	1	1.8	6	10
Missing	3	1.8	1	4.5	-	-	2	3.6	-	-
Total	165	100	22	100	27	100	56	100	60	100

Appendix C-14 *Perceived Learning Outcome of Multimodal Presentations (2)*

Type	Total		Psychology		Dentistry		Education		Medicine	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Multimodal (basic)	27	16.4	2	9.1	2	7.4	16	29.1	7	11.7
Basic Multimodal	36	21.8	3	13.6	8	29.6	13	23.2	12	20
Complex Multimodal	88	53.3	17	77.3	16	59.3	23	41.1	32	53.3
Don't know	12	7.3	-	-	1	3.7	3	5.4	8	13.3
Missing	2	1.2	-	-	-	-	1	1.8	1	1.7
Total	165	100	22	100	17	100	56	100	60	100

Appendix C-15 *Multimedia and Signaling Predicted by AtMP*

	Multimedia [a]			Signaling [b]		
Predictors	*B*	*SE B*	e^B	*B*	*SE B*	e^B
Constant	1.52	0.21		3.27***	0.44	
AtMP	0.42	0.03	1.04	0.10	0.07	1.11

Note [a] n = 161. R^2_L = .01, R^2_{CS} = .01, R^2_N = .02. Model χ^2 (1) = 1.46, p = .23.
[b] n = 160. R^2_L = .04, R^2_{CS} = .01, R^2_N = .05. Model χ^2 (1) = 2.21, p = .14.

Appendix C-16 *Multimedia and Signaling Controlled*

	Multimedia [a]			Signaling [b]		
Predictors	*B*	*SE B*	e^B	*B*	*SE B*	e^B
Constant	2.13*	1.08		2.91	2.36	
AtMP	0.00	0.06	1.00	0.22	0.14	1.25
Gender by age						
Female (19-24) vs. F (≥25)	0.21	0.82	1.23	-0.25	1.87	0.78
Male (19-24) vs. F (≥25)	-0.57	0.91	0.57	-1.05	1.97	0.35
Male (≥25) vs. F (≥25)	0.28	0.67	1.32	-2.25	1.65	0.11
Lecturers' Didactic Awareness	0.39	0.24	1.48	-0.89*	0.42	0.41
Lecturers' Media Literacy	-0.49	0.26	0.61	1.05	0.64	2.85
Students' Media Literacy	0.26	0.23	1.30	0.10	0.44	1.11
Grade Average						
≥D<C vs. ≥B<A	-0.16	0.96	0.85	-17.47	4235.40	0.00
≥C<B vs. ≥B<A	1.44	1.01	4.22	16.87	4712.23	21260306.86
Study programme						
Psychology vs. Medicine	0.09	1.27	1.09	24.24	7321.66	33726843153.56
Dentistry vs. Medicine	1.67	1.23	5.31	-3.02	1.62	0.05
Education vs. Medicine	-1.00	1.22	0.37	14.59	4235.40	2170541.96

Note [a] n = 154. R^2_L = .14, R^2_{CS} = .12, R^2_N = .20. Model χ^2 (12) = 19.63, p = .08.
[b] n = 153. R^2_L = .38, R^2_{CS} = .12, R^2_N = .42. Model χ^2 (12) = 19.45, p = .08. Estimation was terminated at iteration number 20 because maximum iterations had been reached, a final solution could therefore not be found and the model is thus not viable.

Appendix D Equations

One-way analysis of variance.

$$\omega_2 = \frac{\mathrm{SS_M} - (df_\mathrm{M})\mathrm{MS_R}}{\mathrm{SS_T} + \mathrm{MS_R}} = \frac{26.9 - (3).84}{159.1 + .84} = .15$$

Appendix D-1
Calculated omega squared

$$est.\,\omega^2 = \frac{df_{bet}(F-1)}{df_{bet}(F-1) + N_T} = \frac{2(74.54-1)}{2(74.54-1)+162} = .48$$

Appendix D-2
Estimated omega squared

Pearson's correlation.

$$r = \frac{cov_{xy}}{s_x s_y} = \frac{-4610.619}{(155-1)(5.949 \times 6.220)} = -.8091 = -.81$$

$$t_r = \frac{r\sqrt{\mathrm{N}-2}}{\sqrt{1-r^2}} = \frac{-.81\sqrt{155-2}}{\sqrt{1-0{,}6561}} = -17.084 = -17.09$$

Appendix D-3
Calculated Pearson's correlation and t-statistics

Biserial correlation.

$$r_b = \frac{r_{pb}\sqrt{pq}}{y} = \frac{.09\sqrt{0{,}828 \times 0{,}172}}{0.2541} = .13$$

Appendix D-4
Biserial correlation

In the equation above the biserial coefficient between the multimedia principle and AtMP was calculated on the basis of the point-biserial coefficient (r_{pb}), the largest portion in the predictor variable (p), the remaining portion (q) and the ordinate of the normal distribution (y).

The analyses indicated a weak positive relationship between the two variables (R^2 = 1.69%), but a computed z-score from Appendix D-5 revealed that the probability level was greater than .05, and the result was therefore not statistically significant.

$$Z_{r_b} = \frac{r_b - \bar{r}_b}{\mathrm{SE}_{r_b}} = \frac{.13 - 0}{\frac{\sqrt{pq}}{y\sqrt{n}}} = \frac{0.13}{\frac{\sqrt{0{,}828 \times 0{,}172}}{0.2541\sqrt{161}}} = 1.11$$

Appendix D-5
Biserial correlation - z-score

Multiple regression. The following example is based on section 4.4. Since the computation of intercept and unstandardized coefficients are fairly non-existent when operating with one categorical variable, the use of matrix algebra in the following section may seem redundant, but the methods are meant to demonstrate the procedure for more multifarious conditions (e.g., *RQ4: Hierarchical Multiple Regression*). A logical first step is to calculate each of the coefficients, and like the aforementioned correlation coefficients these could be presented standardized on the same scale (ranging from ±1) or as unstandardized covariance. To calculate the standardized coefficient (β) one may use the formula below, which in this example results in the standardized coefficients for AtMP.

$$\beta_i = r_{ii}^{-1} r_{iy} = \begin{bmatrix} 1.192 & 0.357 & .453 \\ 0.357 & 1.221 & .493 \\ 0.453 & 0.493 & 1.287 \end{bmatrix} \begin{bmatrix} .277 \\ .223 \\ .266 \end{bmatrix} = \begin{bmatrix} .52989 \\ .50241 \\ .57817 \end{bmatrix}$$

Appendix D-6
Standardized regression coefficients

Where β_i is the matrix of standard coefficients r_{ii}^{-1} is the inverse matrix of intercorrelations between the predictor variables and r_{iy} is the matrix of correlations between the criterion and the predictors. An inverse correlation matrix, like an ordinary correlation matrix, is not difficult to calculate, but it can be quite time-consuming and the equations are prone to rounding errors, hence the matrices are produced by SPSS (J. Cohen et al., 2003, p. 661; Harris, 2001, p. 493). From the correlation matrix between the criterion and the predictors, and the matrix of unstandardized coefficients one may compute the coefficient of determination (R^2).

$$R^2 = \beta_i r_{iy} = [.530 \quad .502 \quad .578] \begin{bmatrix} .277 \\ .223 \\ .266 \end{bmatrix} = .0.413$$

Appendix D-7
Coefficient of determination

Furthermore, the coefficient of determination can be used to assess the significance of the model using an F-ratio.

$$F = \frac{(N-k-1)R^2}{k(1-R^2)} = \frac{(162-3-1).41268}{3(1-.41268)} = 37.006$$

Appendix D-8
Significance of regression model

The unstandardized coefficients can be calculated by dividing the standard deviation of the criterion variable by the standard deviation of the predictor and multiplying the total with the standardized coefficient.

$$B_i = \beta_i\left(\frac{S_y}{S_i}\right) = \begin{bmatrix}.52989\\.50241\\.57817\end{bmatrix}\begin{bmatrix}\frac{5.93309}{0.34364} & \frac{5.93309}{0.37383} & \frac{5.93309}{0.47501}\end{bmatrix} = \begin{bmatrix}9.1489\\7.9738\\7.2216\end{bmatrix}$$

Appendix D-9
Unstandardized regression coefficients

To assert the significance level of the regression coefficients one may calculate a t-score from the division of the coefficient by its standard error.

$$t = \frac{B_i}{SE_{B_i}} = \frac{\beta_i\left(\frac{S_y}{S_i}\right)}{\frac{S_y}{S_i}\sqrt{\frac{1}{1-R_i^2}}\sqrt{\frac{1-R_Y^2}{n-k-1}}}$$

$$\begin{bmatrix}9.1489\\7.9738\\7.2216\end{bmatrix} \div \left(\begin{bmatrix}17.2675\\15.8724\\12.4907\end{bmatrix}\begin{bmatrix}1.0911\\1.1044\\1.1338\end{bmatrix}\right)[0.0610] = \begin{bmatrix}7.9606\\7.4568\\8.3597\end{bmatrix}$$

Appendix D-10
Standard error and t-value for B

Where R_i^2 and can be calculated in the manner of Appendix D-7, and is the proportion of variance accounted for in the predictor variable of interest by the other predictors. Since all the coefficients have a t-value greater than 2.6073 one may consider them statistically significant at $p < .001$. The last piece of the puzzle in evaluating the model is the intercept, which can be computed using the following equation,

$$B_0 = \bar{Y} - \sum_{i=1}^{k}\left(B_i\bar{X}_i\right) = 1.4197 - \left(\begin{bmatrix}9.1490\\7.9738\\7.2216\end{bmatrix}\begin{bmatrix}0.1358\\0.1667\\0.3395\end{bmatrix}\right) = -3{,}603$$

Appendix D-11
Regression intercept

where B_0 is the mean of the criterion ($\bar{Y}$) less the sum of the unstandardized coefficient matrix multiplied by the matrix of predictor means. By using Equation 5 one may compute the predicted value of the criterion, but due to the binary nature of the predictors the equation would be rather uninteresting. The reason for this is that only one indicator variable can be active (i.e., “1”) at any given time. Hence, if all the indicators are inactive, then the predicted value of the criterion will be the intercept and the mean of the baseline category (in this case the medicine students) or otherwise the mean of the active indicator and the concurrent study programme.

Logistic regression.

Appendix D-12
Log-likelihood

$$\lambda = \sum_{i=1}^{N} [Y_i \ln(\hat{p}_i) + (1 - Y_i)\ln(1 - \hat{p}_i)]$$

$$\lambda_0 = -52.3099 \ = \ -.6082(86) = 0 + \ln(1 - .4557)$$

$$\lambda_1 = -56.5863 \ = \ -.7859(72) = \ln(.4557) + 0$$

Appendix D-13
Pseudo-R²

$$R_{\mathrm{L}}^2 = 1 - \frac{-2(D_i)}{-2(D_0)} = 1 - \frac{-2(-104.9901)}{-2(-108.8962)} = .0359$$

$$R_{\mathrm{CS}}^2 = 1 - e^{\left[-\frac{2}{n}(D_i - D_0)\right]} = 1 - e^{\left[-\frac{2}{158}(-104.9901 - (-108.8962))\right]} = .0482$$

$$R_{\mathrm{N}}^2 = \frac{R_{\mathrm{CS}}^2}{1 - e^{\left[\frac{2(D_0)}{n}\right]}} = \frac{.0482}{1 - e^{\left[\frac{2(-108.8962)}{158}\right]}} = .0644$$

Appendix D-14
Odds-ratio

$$\Delta \mathrm{e}^{\mathrm{B}} = \frac{\mathrm{e}_1^{\mathrm{B}}}{\mathrm{e}_0^{\mathrm{B}}} = \frac{\left[\frac{\hat{p}_1}{1 - \hat{p}_1}\right]}{\left[\frac{\hat{p}_0}{1 - \hat{p}_0}\right]} = \frac{\left[\frac{0.4457}{1 - 0.4457}\right]}{\left[\frac{0.4263}{1 - 0.4263}\right]} = \frac{0.8041}{0.7431} = 1.0821$$

Where $\hat{p}_0$ and $\hat{p}_1$ are the probabilities of the criterion being one, before and after a one-unit change in the predictor respectively.