END-USERS ANALYSIS

STEAM

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This project aims at developing a Serious game to train experts in advanced multimodality.

The project runs from September 1st 2016 to August 31st, 2019 (36 months), it involves 5 partners (MANZALAB, France, VUC Storstrøm, Denmark, Seinäjoen koulutuskuntayhtymä, Finland, Akademie für berufliche Bildung gGmbH, Germany, COVENTRY UNIVERSITY, UK) and is coordinated by Manzalab.

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3	Akademie für berufliche Bildung GmbH	AFBB	Germany
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Abbreviations

CPD	Continuous Professional Development
HE	Higher Education
IWB	Interactive White Board
VARK	Visual, Aural, Read/write, and Kinaesthetic

1 INTRODUCTION

The D1.1 'End-users analysis' report provides a review of and analysis on the use of multimodality in teaching and learning. The document provides a description on what constitutes multimodality for teaching and learning in terms of how it is perceived and approached by educational institutions, schools and students in Europe. The aim of D1.1 is twofold: (1) to analyse, describe and present evidence on multimodal learning and teaching including tools, processes and pedagogical strategies deployed by key stakeholders for enabling multiple models of learning and teaching and (2) to carry out a survey with the STEAM's end-users for eliciting their understanding on multimodality and how it is approached by them. The survey paves the way for perpetuating aspects of multimodal teaching and learning deployed by the 3 end-users of the project: SEDU, VUCSTOR and AFBB.

The literature review started by forming the research questions to be addressed, the search strategy adopted, data collection and analysis processes used and determining the quality of the studies retrieved. Then, the results of the literature study are presented and thematised into categories with headings representing the multimodality aspect in question.

The survey analysis started by designing the data collection method- an online questionnaire with associated questions to help demarcate the level of understanding and uptake of multimodality for teaching and learning in the associated countries. We used a comparative approach to analyse the findings emerged from the questionnaire. The findings are not discipline-specific hence they can be used as a generic framework for elucidating on ways, tools, discourses, strategies and practices taken forward for improving the design and delivery of teaching and learning with the use of multimodal approaches.

A set of recommendations are provided on developing the multimodality serious game and on multimodal teaching, learning and research stemming out from the literature study and survey.

2 METHODOLOGY

The review of evidence presented in this report is based on the process of designing a strategy for retrieving, appraising, extracting, synthesising, interpreting and assessing relevant literature in the public domain (Gentles et al., 2016). To fit the nature of the evidence-base and the purposes of the small-scale character of this deliverable, an evidence-based approach was adopted as illustrated in Figure 1 and explained briefly in this section.

Figure 1 An evidence-based approach to reviewing multimodality in learning and teaching

2.1 FORMULATING RESEARCH QUESTIONS

The characteristics of contemporary education are increasingly theorised as networked, data-driven and visually represented. These conditions underpin the emerging landscape as it is shaped by the advent of new persuasive technologies and novel pedagogical modalities. These shifts and developments have significantly influenced teaching and learning practice in terms of the processes, methodologies and services utilised for enhancing the student learning experience. A key aspect of this is the readjustment of representational, communicational and didactic resources of writing, image, audio, tactile, gestural and spatial representations in new multimodal instantiations (Jewitt, 2008). In the first part of this report we investigate *meanings, practices and discourses* in school multimodality. Against this background, the overarching questions are:

(1) What multimodality means for teaching and learning in secondary schools and universities? and

(2) How multimodality is approached and practiced for enhancing teaching and learning in secondary schools and universities?

2.2 SEARCH STRATEGY

The search strategy consisted of 2 researchers discussing about the types of resources perpetuating the Corpus and how such resources are going to be retrieved, organised and interpreted. We prepared a list with the available options for retrieving resources and the criteria necessary to be deemed as purposeful for our study.

The main evidence base from the discussion that follows on multimodal learning and teaching is drawn from a range of resources including mainly journal articles and conference papers. Some additional items include book chapters. The search is conducted principally via Coventry University Library's 'Locate' resource database which provides access to scholarly databases. We have parametrised the search per subject (education), format (articles, books and conference proceedings), date (204-2016), Language (English) and collection (ScienceDirect, IEEE conference publications, SpringerLink Open Access and ACM digital library). In conjunction to this, Google Scholar was used for retrieving items from resources other than the ones included in the database search. All database searches were conducted in winter 2016.

We have gathered 101 papers in total, including 68(67.3%) journals, 20(19.8%) book chapters, and 13(12.8%) conference papers. 18 (17.8%) articles report in variation in meanings about multimodality, 46 (45.5%) report on multimodality approaches using technology, 17(16.8%) report on teacher training on multimodality and 12(11.8%) on serious games as a digital and multimodal sources of learning.

2.3 DATA COLLECTION

Normally using Boolean and Proximity search the term 'Multimodality in Learning and Teaching' was combined with specific technology intervention identifiers (e.g. serious games, virtual learning environments, learning management systems, massive open online courses) and teaching approaches, methods and strategies identifiers, to retrieve items only where these combinations featured in title and/or abstract fields. Items relating to information literacy and multimodality were included as becoming information literate designates a learning process that encompasses the use of semiotics for making meaning. Multimodal ensembles such as speech and writing were also included but only for formulating diverse understandings and meanings of multimodality. Detailed technical descriptions of multimodal resources and specificities of their development process were excluded. Items were included in the review corpus if they:

- Included the term multimodal education or close synonyms such as multimedia resources, many modes of learning, modes of communication and semiotic resources.

- Reported on multimodality for learning and teaching.
- Reported on multimodality for teaching and learning in schools.
- Reported on multimodality encompassing the use of technology for enhancing learning and teaching
- Were written in English
- Were published between 2004 and 2016 with the exception of selected prior items.

Where it did not prove possible to acquire the fool text of some items for which title and/or abstract were available, these items normally were excluded. In some cases, titles and abstracts do not highlight the primary or secondary focus of the article; some useful items therefore may have slipped through the net. Sources providing access to Masters and PhD theses were not searched and items written in language other than English were not retrieved.

Given the nature of the STEAM as it is not a research-intensive project, we did not aim for comprehensiveness or to adopt a full scale systematic review. However we believe that the corpus provides a reliable representation of the current evidence-base on 'multimodality for teaching and learning'.

2.4 DATA ANALYSIS

Data analysis has been carried out by two (2) researchers against the coding framework presented below. The researchers categorised all items in the corpus based on the coding identified.

Table 1 Coding framework

Coding	Description
Resource identifier	Title, author, date of publication
Resource type	Research report, journal article, conference paper, book chapter
Variation in multimodality meaning	How multimodality is defined, conceived. Analysing key concepts such as mode, semiotic resource, materiality, modal affordance. The role of meaning in multimodality.
Approaches to using multimodality	What pedagogies, teaching and learning strategies are used?
Multimodality teaching with the use of technology	How multimodal teaching is practiced with the use of technology. How digital technologies (games, Web2.0) are changing ways of communication and introduce new types of interactions
Best practices in multimodal teaching	Innovative ways of multimodal teaching and learning
Multimodal teacher training and CPD	Using multimodality for training teachers to enact multimodal teaching in the classroom
Serious games as a digital multimodal source of learning	How serious games are used to advance learning, teaching and training? What in-game modes / characteristics / mechanics are increasingly used?
Role of the teacher/trainer in designing and delivering multimodal content	What the teacher is doing in multimodal learning? How he is designing the course? How is he designing learning activities, feedback and assessment?
Role of the student in learning with multimodal content	How students learn in many modes? How they construct meaning? What strategies they use?

2.5 QUALITY OF STUDIES

To assess the quality of the papers in the corpus in terms of their empirical evidence and the rigorousness of the methodology used, each paper was examined and given a score of 1-3 across the five dimensions used by Connolly et al. (2012). Papers were coded as High = 3 e.g. grounded theory, RCT; Medium = 2 (e.g. evidence-based lit review, content analysis) and Low = 1 e.g. case study, pre-/post-test design. The questions that helped to determine the quality of studies were:

1. How appropriate is the research design for addressing the two research questions?
2. How appropriate are the methods and analysis?
3. How generalisable are the findings of this study to the target population with respect to the size and representativeness of the sample?
4. How relevant is the particular focus of the study for addressing the questions of this review?
5. To what extent can the study findings be trusted in answering the study questions?

Coding of the papers was carried out by 2 experienced coders who reflected on coding and discussed how problematic coding may be tackled.

3 LITERATURE REVIEW RESULTS

3.1 WAYS OF UNDERSTANDING MULTIMODALITY

There is an increasing body of evidence which suggests that multimodality in learning is an active, student-centred approach in which students select the resources mostly relevant to them. This means that students are responsible for organising learning content such as words and images into coherent verbal and visual models which comprise their mental schemata and conceptual structures (Mayer, 2001). The essence of multimodality therefore is to provide different types of resources to the student for stimulating learning in meaningful ways (Antonietti and Giorgetti, 2006) within and across disciplines (Jewitt, 2008). To this end, multimodality is described as an inter-disciplinary approach drawn from social semiotics with an emphasis on communication and representation as means to meaning making (Jewitt, 2013). This is directly relevant to teachers in terms of doing more than simply using current theories of learning to engage students with novel forms of modes and resources of learning (Hassett and Curwood, 2009). To achieve this, teachers need to understand how multimodality engender new teaching and learning processes, strategies and methods as well as new roles for the student and the teacher. Multimodality in today's classrooms refers to 'multiple' modes of representation, with combined elements of print, visual images and design. This transitional shift from print-based education to multimodal education indicates the need to rethink how teaching and learning is conceived, approached and practiced. This is conducive to the way pedagogies, content and technology is designed and utilised for allowing multimodality to take place within contexts and social relations (Hassett and Curwood, 2009).

A mode is defined as a socially and culturally shaped resource for meaning making (Bezemer and Kress, 2008). This is conducive to social theory of practice which emphasises the inherently socially negotiated character of meaning and the interested concerned character of thought and action of persons-in-activity (Lave, 1991).This is related to how technologies are conceived and practiced within local and global contexts. As such it is less than the technology itself and more about the social practices within technology is used, including the mechanisms that teachers incorporate to create meaning to students. In essence, multimodality emphasises situated action, considering the social

context as the key factor for meaning making, with special focus on how people are using the resources available based on their own cultural practices, personal beliefs and institutional contexts; rather than emphasising the attributes and behaviours and the system of the available resources. This introduces new possibilities for investigating, analysing and understanding the different ways in which people use multimodality for creating, sustaining and transferring meaning to inter-related ecosystems and social contexts.

3.1.1 Historical development

Multimodality is not a new concept as it has been developed in early 2000s (Jewitt, 2009; Kress and Leeuwen, 2001). The most connected term to multimodality is *multi-literacy* or *multimodal literacy* which transcends the basic idea of reading and writing in multiple forms of print-mixed representations (Miller and McVee, 2012).

Linguistic ideas of communication as static social semiotic systems were firstly researched. Investigations then shifted to language as social systems to understand how language is shaped in relation to the ways people are using it (Kress et al., 2001). Then it was another developmental progression from language to visual texts. Kress and van Leeuwen (2001) argue that there is a clear distinction between 'monomodality' and 'multimodality'. The former engender without any form of illustration and had the same graphical uniform. Academic disciplines were monomodal in the sense that there were only single languages to speak about language, art, music and so on. Each had its own methods, assumptions and technical vocabulary. Kress and Leeuwen (2001) continue to argue that this dominance of monomodal practices started to reverse to cross the boundaries between the various science, art and design disciplines, towards multimedia events, activities and teaching and learning instantiations.

An interesting idea, as a prospect of extending the basic tenets of multimodality, is the shift from linear, bounded and framed specialist tasks to a more non-linear, ill-defined and multi-purposeful applications of semiotic principles. For example, music can not only encode emotion, it can also encode action, or images to encode emotion. This is part of contemporary semiotic practice where different nodes have technically identical processes of development at some level of representation and can be implemented by one multi-skilled specialist. The point of departure for multimodality is therefore the semiotic rather than the technical element. Kress (2001) stressed the semiotic character of multimodality by denoting the social character of meaning through the concept of the 'motivated sign' in terms of the materiality and processes children use to engage with text and how semiotic resources and signs are interpreted by them.

The general problem in relation to *Modality Theory* that research is attempting to shed light is: the identification of the input/output modalities of any given information that may comprise an optimal solution to the representation, use, share or repurpose of that information during task performance (Bernsen, 2001). This seems to be a challenge for multimodal researchers since there are many monomodal modalities to consider the different connections between such modalities.

3.1.2 Overarching concepts

The term *'mode'* refers to a set of resources, created from a social and cultural perspective, that help on constructing meaning. Examples of modes may include writing, image (both static and dynamic), sound, speech, gesture, gaze and posture. The term *'modality'* means a way of exchanging information between humans or between humans and machines (Bernsen, 2001). The term *'semiotic resource'* is similar to the mode as it refers to a means for meaning making that may be a cultural, social or material simultaneously. It is the medium therefore that connects representational resources with how people are using them hence semiotic resources have a meaning potential based on how they have been already used and a set of affordances based on possible uses influenced by the social contexts within which are practiced (van Leeuwen, 2005). The term *'materiality'* refers to how modes are materialised to semiotic resources offering specific potential and constraints for constructing

meaning. *'Modal affordance'* refers to the potentialities and constraints of the different mode – what is possible to communicate or represent with resources of a mode, and what is less possible to accomplish with specific resources of a mode (Kress, 2010). *'Multimodal ensembles'* consist of representations or interactions of more than one mode. Multimodal ensembles can be perceived as distributing a meaning of a message across a number of modes and not on individual modes. Any mode in the ensemble is currying part of the message and combined together comprise the total meaning of the message. Each individual mode is therefore partial in relation to the meaning as a whole (Kress et al., 2005). Current trends on multimodality research are focusing on investigating the interplay between modes and how each mode interacts with and contributes in pertaining the meaning in its entirety (Jewitt, 2013).

3.1.3 Variation in meaning making

We argue that multimodality is based on the process of creating meaning through connecting and combining different modes, semiotic resources, modal affordances and semiotic ensembles. Meaning is perceived as a social action triggered by people's beliefs and situated choices. Jewitt (2013) identifies three categories of meaning choices or meta-functions that are made by people when they communicate:

1. Ideational meaning: Choices related to how people interpret content meanings.
2. Interpersonal meaning: The resources people use to represent the social relations between themselves and those they are communicating with.
3. Textual and organisational meaning for example the choice of resources such as layout, pace, and rhythm for understanding the structure of a text or interaction.

Cope and Kalantzis (2009) asserted that different meanings and meaning-making systems should be addressed with open-ended questions such as:

1. Representational: What do the meanings refer to?
2. Social: How do the meanings connect the persons they involve?
3. Structural: How are the meanings organised?
4. Intertextual: How do the meanings fit into the larger world of meaning (i.e. multimodal ensembles)?
5. Ideological: Whose interests are the meanings skewed to serve?

3.2 MULTIMODALITY AND DIGITAL TECHNOLOGIES FOR LEARNING, TEACHING AND TRAINING

The advent of digital technologies for supporting learning, teaching and training has supplemented or amplified conventional non-digital activities. Digitisation of administrative and routine tasks such as storing, transferring and retrieving information supplements traditional teaching and learning processes in the sense that the digital modalities used and the semiotic resources deployed, do not resemble or offer something new or novel to the way current teaching and learning processes and strategies are practiced. Indeed learning technologies should help students to increase their capacities for innovation, leadership, multi- and inter- disciplinary collaboration, emotional intelligence, critical skills, collective problem identification and resolution in a participatory digital learning environment (Greenhow et al., 2009).

Multimedia resources and tools in these environments may include for example, interactive videos and images, recorded lecture presentations, online quizzes, discussion forums (synchronous and asynchronous), visual representations of student data to depict progress (summative analytics) and on what the student is doing to learn (Sharples et al., 2016). The increasing use of multimedia in teaching

and training provides opportunities to present multiple representations of content (text, images, video, audio, pervasive media) to accommodate different teaching strategies, learning outcomes, assessment methods and feedback mechanisms. Key aspects are to use a plethora of tools, resources, services in a pedagogically-driven way for the purpose of improving the student experience. It has also been argued that increasingly by incorporating multimedia learning in different modes, students may be encouraged to develop a more flexible and inquiry-based approach to learning as activities are designed towards amplifying investigation and inquiry skills with the use of varied semiotic resources (Hazari, 2004). Mayer (2001) argues that student's learning becomes deeper and more meaningful when an array of interactive tools and resources are deployed rather using text alone. Shah and Freedman (2003) identified a list of benefits of using visualisations in learning such as (i) providing external representation of information, (ii) deeper learning, (iii) triggering student's attention and concentration by making information more comprehensive, hence simplifying ill-defined concepts and ideas.

3.2.1 Multimodality as a meaning for teacher-directed teaching

In more traditional classroom settings, oral communication modes were predominant. A teacher-centred approach is based on the "shaping" of learners' behaviour and emphasises the reinforcement, memorisation and repetition of desired actions, underpinned by the fundamental principles of behaviourism (Burton et al., 1996). The teacher transmits the knowledge while the students are the passive audience, memorising the information without necessarily understanding or practicing it (ibid.). The main written communication mode in teacher-centred classrooms is the textbook; closely following and well-connected with the curriculum predefined by the institution or country (Kalantzis and Cope, 2010). The students are producing written texts (e.g. written assignments or tests) having only one person as their audience, the teacher. Evaluation of students' progress and knowledge is happening via summative assessment, a quantitative score (ibid.). The teacher had the major role in the traditional classroom (i.e. sage on the stage), managing the classroom's administration, orchestrating the classroom talk, marking the students' written tests and directing the students to the textbooks. Teaching discrete skills in small steps (e.g. drill and practice) and rewarding students when intended goals have been reached are predominant characteristics of teacher-centred multimodal teaching. Less emphasis is given to student's own interests and ideas because it is of central importance for the teacher to cover the curriculum for making sure that the subject matter is completed by the end of the term. Student's social skills and the utilisation of peer-interaction and networked learning for community-oriented learning are not encouraged. Transmissive teaching with uni-modal, non-interactive tools for content transfer and basic skill acquisition are the focus of attention. Research evidence shows that teaching practices are influenced by educational tradition, historical background, the school system, teacher's beliefs of teaching and learning and the accepted curriculum aims for learning at school (Lerkannen et al., 2016; Schoorman et al., 2007).

We are not claiming that teacher-directed practices are not appropriate for multimedia learning. Teacher-directed practices using semiotic tools have been shown to contribute positively to knowledge and skills in early school years. For example, Stipek et al. (1998) showed that teacher-directed practices in early school years helped students to acquire letter and reading knowledge. Also, students with diverse backgrounds such as low-income students or students with special needs seemed to improve the basic skill development adopting a teacher-directed approach (Lerkannen et al., 2016).

3.2.2. Multimodality as a meaning for student-centred learning

Multimedia learning is connected to an active, student-centred approach in which students are directing their own learning based on their interests and prior knowledge. Students may select relevant words and images and organising them into coherent verbal and visual models. In the teaching and learning spectrum, a plethora of semiotic tools and resources are being used both by the teacher for facilitating students to apply, analyse, evaluate and create new knowledge; but also by the

students themselves to support their own understanding, unleash their creativity, experiment and solve ill-defined problems. Tools utilised for allowing students to apply, experiment and create might involve serious games, virtual worlds, virtual reality, virtual learning environments and Massive Open Online Courses. These modes and semiotic resources help students to create, apply and transfer meaning within their own social context and this signifies the importance of stretching teaching and learning practice beyond the potentialities and constraints (i.e. mode's affordances) of the normal classroom. In addition such technologies enable to move beyond the standard forms of written and spoken language to connect with the culturally and linguistically diverse landscapes and the multimodal texts mobilised across these landscapes (Jewitt, 2008).

Student-centred approaches to learning and teaching focus on what the student is doing in terms of the processes and strategies are deployed to learn, how misconceptions are addressed and how feedback is applied for achieving progress and improvement. Multimodality is central for students as means to design, implement, share and re-use/re-purpose semiotic resources and multimodal ensembles (Greenhow et al., 2009). For example, students are constructing learning through content and resources found online and offline, in various places such as in the school, in field trips, in the library, in museums and science centres. This blending of learning spaces between formal (school setting) and informal (out-of-school setting) enables learning to be approached from multiple perspectives, encompassing actors from various learning settings (e.g. museum curators, scientists, researchers, business experts) having the role of the teacher and thereby provide practical knowledge as experienced by real-world scientists and specialists in the field.

This student-centredness is related to the notion of multiple intelligences (Picciano, 2009) in the sense that they do not exist as a linear equation of 'yes' or 'no' but within a continuum of naive to more coherent ways of learning influenced from the external environment, prior knowledge and the subject domain. This implies the need for a framework that discerns a 'multimodal' design that is characterised by student-direction, activity-led with rich-mediated semiotic resources.

There is a strong convergence between student-centred learning and multimodality as multimodal elements allow learning material to be presented in multiple sensory modes and delivered in varied semiotic resources. This may help students to understand meanings using multiple tools of representation as means to strengthen their understanding via interacting and experimenting with a diverse set of tools and resources.

3.2.3 Pedagogical design principles for multimodal teaching and training

The theoretical background for multimodal teaching and learning is closely related to constructivism. Constructivist learning is context-specific and builds on prior knowledge for constructing new meanings. The fundamental assumption of constructivism is that knowledge is not transmitted directly from one student to another, but is actively constructed by the student and is shared by a wide range of different research traditions relating to science education (Driver et al., 2004). Personal construction of meaning, which is a fundamental tenet of multimodality, resulting from students' interactions with the learning environment is the core commitment of a constructivist position. From this perspective teaching with multimedia may be seen as designing learning activities that challenge students' prior conceptions of learning while encouraging them to apply these prior experiences to new situations. Yet others see it as involving apprenticeship into scientific practices (Lave and Wenger, 1991). Clearly there is a range of accounts of the processes by which knowledge construction takes place and they can be illuminated by a number of constructivist approaches to science teaching (e.g. Hodson, 1998; Appleton, 1993), which can be usefully summarized as follows:

- Help students to make explicit ideas and views by using multi-discourses and semiotic resources. This requires from students to consciously discern at which mode is 'foregrounded' or is 'the focus of attention' and which mode is on the periphery or 'backgrounded' (Kress et al., 2001). This foregrounding – backgrounding relationship may indicate the influence of the mode to helping students to communicate their ideas.

- Create opportunities for students to explore ideas and test their robustness in explaining phenomena, accounting for events and making predictions by initiating multimodal communication.
- Provide stimuli for students to develop, modify and, where necessary change their ideas and views; meaning does not reside in one mode alone; rather meaning it is only understood when we look all the modes together (multimodal ensemble).
- Support their attempts to rethink and reconstruct their ideas and views. This applies to the notion of 'transduction' which represents transition from one mode of representation to another. For example, to scaffold students' effort to re-think and re-construct their ideas, the teacher may represent a foundational concept via speech and gestures and then assign to students to apply what they have learned through a serious game. The use of the serious game may encourage students to re-think, re-interpret and transfer their conceptual understandings through a different mode.

Multimodal inquiry learning

It is evident that many schools across Europe have been focused on print texts as the basic modality for assignments, exercises and for encouraging students to make explicit what it is learned. Besides multimodal teaching and learning and literacy is more than reading and writing (Gee, 1996) to consider the multiple ways we understand the world around us (Freire, 2000). It is through the multiple representations of meanings that is stored in different modalities and semiotic resources that we need to reflect upon (Jewitt, 2008). Commentators argue that there should be a tighter connection between activities outside of the school with activities taking place within the school (Gee, 2004; Falk and Storksdieck, 2005).

We define 'Multimodal Inquiry Learning' as a cluster of learning and teaching approaches in which students' inquiry or research activities are aided through the use of multimedia technologies and semiotic resources'. Students use multiple representations of communication for enabling them to engage actively with questions and problems associated with their subject or discipline. Students use the inquiry methods and practices of the subject to construct and share knowledge. Inquiry learning is an empowering approach with benefits for subject learning as well as a wide range of important high-order intellectual attributes. Successful inquiry learning flows from purposeful engagement with inquiry questions and tasks, in a challenging and supportive learning environment.

The fundamental point of departure is always an authentic question or problem that may be formulated by students themselves, their teachers, or others. Tasks designed to provide a framework for inquiry include problem or case scenarios, field-work investigations, experiential learning projects and laboratory experiments as well as research projects of various kinds. Students' inquiries may be small or large in scale, involving 'whole-cycle' research projects or only specific elements of a larger research process. Often working collaboratively or co-operatively with peers, sometimes in partnership with teachers, students are supported by teachers and others with specialist educational roles (e.g. librarians, learning technologists, or museum educators) to apply the scholarly and research techniques of their academic or professional discipline. Inquiry learning often involves the use of digital resources and tools and may be carried out face-to-face, on-line or in a blended combination of these. Inquiry processes may be highly structured or more flexible, some giving students a large degree of control in the framing and direction of their inquiries and others being more strongly teacher-directed. Not uncommonly, students become involved in self- and peer-assessment of their inquiries, and engage in critical reflection on the process they have experienced. They may be encouraged to share the results of their inquiries with each other and with wider audiences.

In inquiry learning, the inquiry process is to the fore, with all learning tasks, assessments, resources, environments and teaching strategies designed to support learning through an emergent process of exploration and discovery. Use of inquiry approaches in teaching typically reflects strong commitment to educational values and beliefs associated with student-centredeness and learner empowerment, with teachers aiming to encourage students to develop a significant amount of responsibility for their

learning. From the perspective of the inquiry teacher, a key challenge is to establish conditions in which students' inquiries are stimulated and can flourish, and in which they are supported effectively in developing relevant inquiry competencies and other process skills. There is strong and consistent evidence across many studies that provision of appropriate support is essential for productive inquiry learning. A strong focus on the development of process (as well as subject) knowledge and skills is a feature of the intended learning outcomes of many inquiry approaches, including process knowledge and skills that relate specifically to the academic discipline in question and more generic areas (such as information and digital literacy, or group-work, skills).

Multimodal formal and informal learning spaces

A key principle of multimodal learning and teaching enacted with pedagogically-rich resources and strategies, such as inquiry-based learning, is part of a broader learning experience. In this section we focus on the association of multimodal representations of meaning with the broader learning experience across formal (classroom learning, school laboratories and the like) and informal learning spaces (field trips museums and science centres). The success of multimodal learning may largely depend on how successfully a school and/or teacher / trainer will design activities that take place in spaces that students have the opportunity to experience real-world experiences and connect them to the theoretical nuances learned in-class. Current literature in multimodal education echoes the need for greater coherence and integration between informal learning spaces and classrooms, and urges a careful analysis of the objectives of teaching and learning in informal learning environments (e.g. Falk and Storksdieck, 2005; Gerber, Cavallo and Marek, 2001).

In conceptualising the difference between formal and informal multimodal learning, Eshach (2006) describes a field trip to a museum. In the museum students are invited to free unguided visits and may approach different exhibits, themes or spaces. Then students enter the class to hear a lecture, or conduct a scientific experiment while the teacher is guiding the process. Eshach (2006) considers not only the general differences of the physical spaces (in or out of school) but also other factors such as social context, motivation, interest and assessment to distinguish between formal and informal learning. Some authors perceive sharp distinctions between formal and informal learning as inappropriate (e.g. Hofstein and Rosenfeld, 1996) as learning is learning and it is influenced by setting, social interaction, individual beliefs, knowledge and attitudes (Dierking, 1991).

The literature also discusses outdoor learning (Rickinson et al., 2004) and free choice learning (Bamberger and Tal, 2007). One common characteristic of these ideas is that they all address out-of-school learning spaces. The idea of informal learning emphasizes the nature of out-of-school environments that allow the student to identify varied learning options, in different spaces, and finally to select a personal option, theme or space for learning (ibid.). Therefore, the concept of *informal learning* can be used to include all out-of-school activities within museums, zoos science centres and so forth. Informal learning has no authority figure and the learner determines how the desired knowledge will be acquired.

Creating multimodal collaborative activities

There is increasing research on collaborative multimedia learning in different subject domains (e.g. Bell et al., 2010; Kolloffel et al., 2011; Gijlers et al., 2009). Studies have shown that collaboration can enhance the quality of the learning process hence the importance of achieving specific learning outcomes (Dillenbourg, 1999; van Joolingen et al., 2007) combining multimedia content with collaborative learning may lead to engaging, interactive and powerful multimedia learning environments.

Students working collaboratively in groups have the opportunity to share their thoughts and prior knowledge. Collaborative dialogue supports learning by clarifying thinking and consolidating ideas (Hmelo-Silver et al., 2002). The "classroom learning communities" approach seeks to operationalise the benefits of learning through participation in communities of practice (Lave and Wenger, 1991).

Multimodal learning promotes the idea of creating a learning community with a shared purpose of making sense of scientific ideas and practices (NRC 1996; Harris and Rooks, 2010). However, research suggests that knowledge and skill differences may lead to tensions in group-work situations. It is therefore recommended that teachers explain to students the process and ethos of collaborative multimodal learning (Gijlers and de Jong, 2009). Further, collaborative processes are difficult to enact in classrooms in the physical space, time schedules and norms of interaction in schools (Singer et al., 2000).

Learning tasks structured for small groups in which students are engaged in interactions with peers pursuing a common scientific investigation are used extensively in IBSE and it is common in a collaborative situation for higher-skilled students to serve as more experienced peers and thereby help less experienced students. Studies (see for example Rennie et al., 2003; Manlove et al., 2006) indicate that inquiry collaborative learning in small groups is effective if certain components are present:

1. Interdependence between group members for accomplishing a mutual goal;
2. Collective responsibility of group members regarding the task and the difficulties that may arise during the learning activity;
3. Reciprocity between group members in the form of explanations and discussions for solving problems and considering each member's knowledge for producing something new and advanced from the whole group;
4. Social cooperation skills must be shared by each member in order to reach a common goal;
5. Social processes need to be defined in advance for achieving contribution to the group's success.

For students to benefit fully from an inquiry collaborative learning experience, it is important to be engaged in a task-focused and elaborated interaction (Gijlers et al., 2009). If students have conflicting or divergent ideas they must reach consensus before continuing with the discussion. Activities that promote the mere exchange of facts and provision of answers and solutions are not enough for collaborative learning (Anjewierden et al., 2011). Students need to plan and execute the inquiry process, but also to communally select, process, analyse, interpret, organise and integrate information into meaningful and coherent structures (Chu et al., 2011).

Collaboration is perceived as a scaffolding function in inquiry learning. School students have difficulties with several aspects of inquiry including asking questions, making decisions and understanding how information and concepts relate to the overarching question.

Think-pair-share tasks (Wilke and Straits, 2005) allow students to work individually and with peers. Initially, students work independently, thinking about a scientific problem and provide a perceived solution. Then students work in groups to discussing the assigned problem and enhance their understandings based on peer feedback.

Multimodal information literacy

Some approaches to multimodal teaching require students to engage very actively with a wide range of scientific information sources, both digital and other, for example involving independent and guided information-gathering, evaluation, analysis and synthesis. In this context, there is value in explicitly embedding information literacy development activities into multimodal teaching, to support students to further develop their competencies in this area. Teachers and trainers may enhance students' learning experiences by integrating information literacy development into the curriculum (Dennis, 2001).

The concepts of multi-literacy and information literacy both emphasise curiosity, reasoning and critical thinking (Cowan and Cipriani, 2009) and may be seen as complementary. The concept of information literacy encompasses capabilities that are deemed essential for multimodal learning as students have

to identify their information needs, plan and implement a search for information, evaluate the information retrieved and present it effectively. These skills are necessary for learning in all subjects. Librarians see value in integrating information literacy development within the subject curriculum to support students with their learning endeavours, but have faced barriers in their attempts to collaborate with teachers.

Information literacy has been defined as "the adoption of appropriate information behaviour to identify, through whatever channel or medium, information well fitted to information needs, leading to wise and ethical use of information in society" (Webber, 2003). A useful model for understanding the scope of information literacy has been produced by SCONUL (2011). This was designed primarily for use in HE, but it has value for school-level education as well. The diagrammatic representation of the model is reproduced below, and further detail of the competencies included in each 'pillar' can be found on the SCONUL website [1].

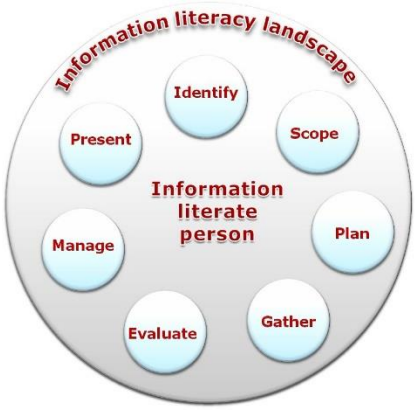

Figure 2 The seven pillars of information literacy

One strategy for information literacy development particularly aligned to multimodal teaching is the use of WebQuests as semiotic exercises for students involving information search, evaluation and use. WebQuests can be applied to almost any subject context, and have been described as "a framework for teachers to structure student-centred learning using Internet resources" (MacGregor and Liu, 2006). WebQuests typically involve the investigation of an authentic problem using resources available on the Internet, and are based on a student-centred, resource-based pedagogy that involves the development of search and critical evaluation skills. MacGregor and Liu (2006) report on a study of WebQuests used in a 4th grade science class. Students demonstrated higher levels of cognition and were required to analyse and synthesise information in order to complete the WebQuest. The authors recommend appropriate scaffolding for students in the form of a study guide and concept mapping techniques.

Digital technologies for multimodal teaching and learning: Serious games

Serious games are referred in the literature as games that combine entertainment, enjoyment or fun with in-game learning activities, teaching strategies and assessment methods that adhere to learning outcomes for the enhancement of knowledge, skills, teaching and learning (Hess and Gunter; Hainey et al., 2011). Digital games have been introduced in higher education with two foci: professional development / training (helping teachers to enhance their teaching practice – e.g. Lameras et al., 2014; Lameras et al., 2016) and learning (helping students to improve the learning experience- e.g. Wouters et al., 2013), paving the way for the term "serious games" or "educational games" (Zyda,

[1] https://www.sconul.ac.uk/

2005; Gee, 2005; Lancaster, 2014). The overarching objective of such games is to make an impact on how content and process can be approached in a different way, in comparison to conventional teaching and learning approaches, by integrating rich mediated content with fantasy, competition and immersion (Alamri et al., 2014). Learning is naturally enacted through the game's mechanics and dynamics that drive player's motivation to learn, sometimes serendipitously and unconsciously, associated content whilst concentrated in achieving s, gain points or completing a level.

There has been increasing demand over the last couple of decades for games that educate and train for becoming teaching tools that may be used for creating interactive, engaging and immersive learning activities. Gee (2003) argues that at minimum, games provide the framework for exploring and learning concepts thus, increasing self-efficacy, collaboration, inquiry and soft skills. Gee (2003) contents that critical thinking and active learning are critical factors for constructing student's learning experience. A game may encourage this critical thinking and active engagement via *the internal design* of the game itself and through the *people* around the learner for reflective meta-discussions thinking and debate during and after gameplay.

Several principles and methods have been used to categorise games as means to understand the purpose of using a particular game type. Evidence from the literature suggests that different methods and tools have been suggested to classify serious games (Sawyer and Smith 2008; Zyda, 2005; Alvarez and Michaud, 2008). The choice of a specific genre as part of a serious games design process might inform learning parameters such as content, teaching strategies and learning outcomes (Laporte et al., 2013) and thereby influencing student's learning experience. The selection of genre addresses aspects related to individual characteristics such as prior experiences in playing games, approaches to learning and associated preferences in terms of how content is conveyed and visualised. Laporte et al. (2013) investigated game genre effects on learning content by exploring the appropriateness of specific game genres for incorporating learning content. Three games were analysed based on a learning vocabulary used to extract themes of relevance such as facts, behaviours and reasoning further decomposed to questions, memorization, association, drill, imitation, feedback, coaching practice, problems and examples. The findings show that specialised learning topics such as programming appears to require a specific type of game and content, other topics more open and social-oriented such as entrepreneurship or sociology may be approached with different choice of genres. It has been claimed though, games that aim to change a particular behaviour, for example games that help students to make a transition from surface to deep learning approaches, the type of game is not as substantial as the behavioural change conducive to the game design.

Lameras et al. (2016) developed a taxonomy for classifying learning attributes to game mechanics for scaffolding teachers' efforts to forge learning design within serious games. It is notable to highlight the importance of making the learning explicit in a balanced way, for providing the opportunity to the student to learn within a structure and failure-free environment. The taxonomy is complemented with a games design planner for teachers and teacher trainers to plan, use, re-use and reflect on the learning elements to be designed and enacted when the teacher designs the game. The teacher therefore is viewed as the game designer and decides on a balanced inter-play between the 'entertaining' and the 'learning' aspects. Anastasiadou and Lameras (2016) identified and clustered learning entities residing in mobile location-based games and noted the emergence of specific learning modes that need to be designed for informal learning. For example, when gathering data in the field, feedback mechanisms should be focused around ways and processes that students deploy to consider their methods and strategies to gather data (e.g. research subject, data type, species, artefacts/ specimens residing in the field trip or museum) in the wild as opposed to gather data in a classroom environment or during desk research.

There is little evidence from the literature, which shows evidence on using games for multimodal learning and teaching. This is due perhaps of the reason that a game itself resembles a semiotic resource comprising different modes (e.g. audio, interacting images, videos, gestures, text, posture). Ibid. empirically tested the impact of multimodality and interactivity to learning and teaching. Ritterfield, Cody and Vorderer (2009) used a partial factorial design showing that multimedia and

interactivity as individual characteristics within games impact learning outcomes, especially definitional knowledge gains. Lameras et al., (2014) showed how a serious game may help science teachers to use inquiry-based learning in the science classroom.

Digital technologies for multimodal teaching and learning: Interactive White Boards

Presentational and visual representation of content is essential for communicating subject matter and improving students' understanding. The affordances of Interactive White Boards (IWBs) may be exploited to explain and visualise content knowledge or for engaging students in activities that require to visually manipulate information. IWBs are perceived as a teacher-centred modality to present students content. Material is presented in advance for presenting it in the classroom while teachers may manipulate content in real-time while students absorb the information provided. There have been debates towards the use of IWBs for more student centred activities. For example, Gillen et al. (2007) found that IWBs are conceptualised as heterogeneous mediational tools to be effectively integrated in teaching for constructing cohesion and continuity.

Digital technologies for multimodal teaching and learning: Web2.0

Based on internet connectivity, the growth of Web 2.0; a set of communication services and practices particularly social in nature, also referred to as "participatory Web", has brought significant changes and has broaden the opportunities for social exchanges and the enhancement of multimodal learning and teaching practices in both K-12 and Higher Education (Baxter et al., 2011). There is a number of the educational activities supported by Web 2.0 tools which have the potential to reconfigure the social aspects of educational practice and bring a multimodal approach to teaching and learning; several of these are illustrated/summarised on the Figure 3 below:

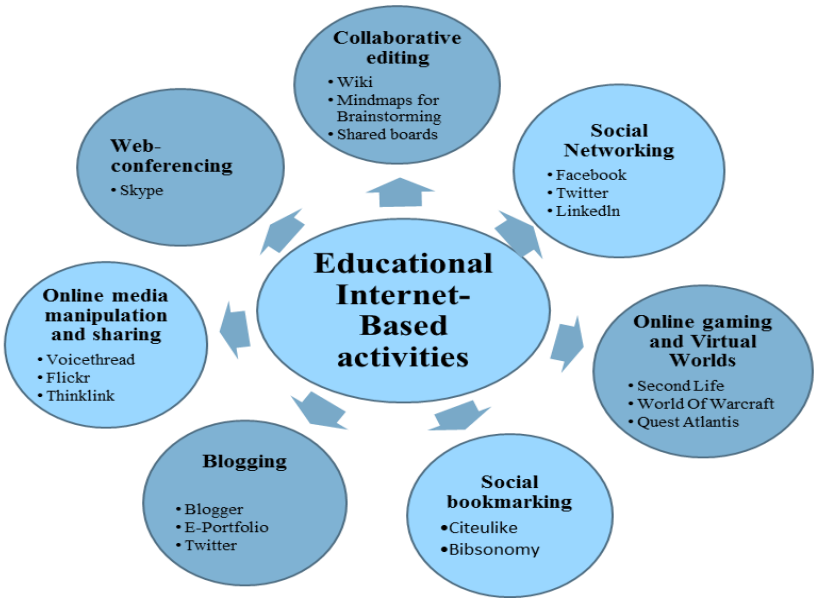

Figure 3 Web 2.0 practices for multimodal teaching and learning

Teachers have started to integrate new educational teaching and learning practices including but not limited to blogging, collaborative editing and online media manipulation and sharing. Blogging applications such as blogger or e-portfolios for example provide the opportunity for the creation of multimodal texts which go beyond the traditional mode of communication (e.g. writing and oral communication); as they integrate not only text-based writing but also sound (speech and music),

images (animated or static) and video and can be shared with others. Blogging enables traditional writing pedagogy, multimodal expression and online interaction. Studies have illustrated that when teachers integrated blogging as a practice, the students exploited the multimodal functions of the technology blogging applications and had significant learning gains. In a research reported by Ferguson, Clough and Hosein (2007), students used distinctive features of blogs including: (1) hyperlinks which enabled the links with external sources "creating a knowledge network", (2) emoticons and images to personalise their entries and (3) feedback via commentary by peers and tutors. In this research, students reported that they felt as members of a research community. They shared useful methods and methodologies, exchanged reflective comments and received peer and tutors support. Moreover, distinctive is also the opportunity that blogging applications such as e-portfolios offer for the emergence of new types of feedback. The integration of audio or audio-visual feedback has the potential to bring a new dimension to a high quality feedback for e-portfolio and other assignments. Research findings corroborate its potential to be more personal, in-depth and engaging in comparison with the written one for students (Bunyan et al., 2008).

The collaborative editing applications such as Wikis and mind-maps may be used for student blogging enabling students and teachers to create collaborative multimodal texts and digital artefacts. Digital tools for mind-mapping for example, are visual instruments that are used in order to demonstrate how different concepts are associated (Fernandes, 2009). These tools can be used either from teacher in order to present a new topic, illustrate the connections between terms/concepts or by students in order to elaborate a task in which they can make logical connections of key-terms, factors and impact of a topic. The basis of this kind of activity is the synthesis of separate ideas into a new visual pattern of thought and they are higher level cognitive tasks (Beetham and Sharpe, 2013).

3.2.4 The role of the teacher in interactive multimodal learning environments

Multimodal learning and teaching is a complex process and success depends largely on how teachers facilitate the multimodal process. Students are expected to work together to gather and analyse data and engage in discussions and debates with their peers and teachers. Teachers play critical roles in designing and scaffolding activities, asking questions to help students verbalise their thinking, and connecting students' ideas with those of the scientific community (Morrison, 2008). Drayton and Falk (2001) argue that checking for student understanding should not focus on removing misconceptions; rather it should allow students to take the time to explain their thinking and to improve their understanding by engagement with evidence from their own experience. However, a dilemma that teachers may experience is the degree of guidance or independence to give to students. Harlen (2004) proposes key elements of the role of the teacher in enacting multimodal teaching:

- Providing experiences, materials, sources of information for students to use directly;
- Showing the use of instruments or materials that students will need in their inquiry;
- Asking open and person-centred questions to elicit understandings and how students are explaining what they find;
- Engaging students in suggesting how to test their ideas or answer their questions through investigation or finding evidence from secondary sources;
- Where necessary, helping students with planning so that ideas are fairly tested;
- Listening to students' ideas and taking them seriously;
- Asking questions that encourage students to think about how to explain what they find;
- Setting up opportunities for collaborative learning and dialogic talk;
- Scaffolding alternative ideas that may explain the evidence from their investigation;
- Gathering information, through observation, questioning and interaction, about students' developing skills and ideas.

It is apparent from the above list that the teacher's role in these environments switches from one of transferring information to students, to guiding and facilitating the learning process by designing

learning activities that focus on student involvement and interaction with peers and resources. There is a need for teachers to be aware of and responsive to potential frustration of the students in the face of inquiry activity that may be complex and ill-defined (Branan and Morgan, 2010). However, the general consensus is that teachers experience difficulties in their effort to develop engaging multimodal resources embedded into learning activities (Miller and McVee, 2013). Teachers find themselves demoralised in changing their practices and integrate new teaching and learning practices. It seems through teachers are more confident and comfortable in teaching what they know best and what they enjoy (Sanders and Albers, 2010).

3.2.5 The role of the student in multimodal learning environments

The writing on a screen using word-processing facilities has been introduced long ago and students have increasingly become familiar with this (Rowsell and Walsh, 2011). However, the continuous development of technologies, digital literacies and pedagogies has brought the need for more advanced forms of writing which could include a blend of writing texts together with quite complex graphics, images and layouts. Thus, the writer-student has become a "producer" of multimodal texts by producing and designing texts which combine images, graphics, sounds and movements on screen. However, in order for students to produce a multimodal text they need to be aware and consider a range of design features including but not limited to composition, layout, combination of text and images/videos as well as the way which these could be appropriate for different audiences (ibid.).

The emergence of new literacies has brought a cultural shift from the consumption of new digital media to their creative production (Buckingham, 2007). Therefore, the students have increasingly become creators rather than consumers of the digital products by using a variety of software to create multimedia presentations, simulations, websites, animations and virtual worlds (Mills, 2010). Studies show that the affordances and the use of multimedia may have significant impact on students learning and especially when it comes to the use of collaborative tools for the production of multimedia texts (ibid.). For example a study reported by Rojas-Drummond, Albarran and Littleton (2008) investigated the collaborative creation of multimedia texts between students aged 9-10 years old. The students were able to combine writing, images and oracy using digital technologies and co-construct knowledge through the production of digital artefacts. Specifically, they developed collaborative creativity via making cross-references between modes and texts and rational connections between events in their text.

The multimodal practices introduce also new roles to students such these of designers and editors of meaning, researchers, writers and interpreters (Miller and McVee, 2013). In interactive multimodal learning environments, the focus is on what the student is doing and the actions enacted for learning are self-direction, construction and reflection. To practice these actions, the student engages in interactive processes such as dialoguing, controlling, inquiring, investigating, manipulating, searching and collaborating (Moreno and Mayer, 2007). For example, with the use of a serious game, the student is controlling the pace of the learning and can manipulate the goals, feedback and activities multiple times until learning is achieved. The parameters of the game and the learning difficulty may be controlled. Knowledge is constructed through interacting with visual characters and in-game missions that emulate real-worlds situations.

Independent learning (Fullan and Langworthy, 2014) is key where students' role is to design, create and transfer learning to existing and new learning contexts. To this line, the role of the student in interactive multimodal learning environments is:

- Meaning-making through the use of multiple modes of learning.
- Acting as a co-learner along with teachers.
- Engage in deep learning activities, cross curricular and complex independent tasks.
- Design clear learning goals based on their own interests and prior knowledge.
- Design assessment aligned to their own misconceptions and future learning.

- Using digital tools and semiotic resources to support students' learning and help master the learning process.
- Give feedback to teachers on how their teaching will be further developed and enhanced as to accommodate personal learning needs.
- Reflecting on own actions.

3.2.6 Technology supported approaches for teacher training in multimodality

Many of teacher education and Continuous Professional Development (CPD) initiatives described in the study making effective use of digital technologies, especially to support pre-and in-service teachers' engagement with examples of real-life practice, their critical reflection and dialogue, and the building of CPD learning communities that often may be based on collaboration between diverse partners. For example, web-based discussion by teachers, teacher educators and science experts was used to support ongoing applications of multimedia learning with special focus on inquiry learning (Songer et al., 2003). In another, online discussion boards were used by teachers and CPD providers to share ideas, discuss lessons and reflect on the nature of inquiry (Luft, 2001). Online reflective diaries have been used to support action research projects (Goodnough, 2008). Online discussion groups have been identified as a way to support teachers who have engaged in multimodal teaching to translate their research experience into pedagogical practice in the classroom.

Digital technologies are recognized as offering powerful ways to support communities of practice and learning communities in education. Barab et al. (2003) describe a professional development programme for which an electronic 'inquiry learning forum' was created to support a virtual community of pre-and in-service teachers. A key aspect of this was its 'virtual classrooms' in which members could post video recordings of their classroom activities along with reflective commentaries, lesson plans and examples of students' work, and were able to illustrate how lessons connected to the national *Standards*. Online discussion spaces called 'inquiry circles' were designed for members to share their virtual classrooms, announcements, web links and electronic documents, collaboratively create documents, and connect with other members. In addition there were general forum discussion spaces, and a library of resources. The authors emphasise the need to consider both the technical and social aspects of design of an online community, finding that this online community worked best when supported with face-to-face interactions. It was found that an online community supported with appropriate resources allowed for highly flexible professional development that is appealing to teachers.

Digital video recording technology is commonly used, for example to record teaching practice in inquiry classrooms that then can be used to support action research projects and to facilitate collaborative reflective dialogue on teaching (Lebak and Tinsley, 2010). In another project, following a CPD programme, teachers created new lesson plans and video recorded their implementation. They then received feedback on the video recorded lessons from university educators (Blanchard et al., 2009). Video recordings of teaching practice and professional development workshops also were used to support reflection in the project described by Rushton et al. (2011) and Singer et al. (2011). Some initiatives have made effective use of videoconferencing. For example, Pringle et al. (2010) describe a distance-learning programme for CPD featuring the use of videoconferencing technology. Following a week long face-to-face workshop teachers participated in monthly videoconferences lasting for two hours. These were used to share best practice and feedback on classroom events and were reflective in nature. Prior to each videoconference teachers completed set tasks and shared documents online.

Advances in technology also are providing teachers with enhanced access to scientific research data. Following changes in the policies of research funding bodies internationally, increasingly large amounts of scientific research data are being made accessible via the web. This provides new opportunities for teachers to conduct authentic inquiry in CPD and in their classrooms. For example, McLaughlin (2010) describes an initiative in which, following an inquiry field trip to research centres,

teachers were given access via the web to research data that would enable them to continue to develop inquiry in school classrooms.

Pre-service and in-service teachers working together

An apprenticeship model has been used in the context of pre-service teachers apprenticed to experienced teachers in multimodal classrooms, framed as 'co-teaching' (Eick and Dias, 2005). Co-teaching in a supportive environment is found to increase confidence in using multimodality (Astor-Jack et al., 2007; Eick and Dias, 2005). The co-teaching relationship can be casted more as 'mentoring' whereby pre-service teachers observe, model and teach under the supervision of more experienced teachers, with positive outcomes (Fazio et al., 2010). Pre-service teachers are much more likely to use multiple modes of learning and teaching if they have seen their mentors using it and training of mentors has been identified as an important aspect of programmes in which experienced teachers mentor pre-service teachers in multimodality (Lotter et al., 2009). The involvement of pre- and in-service teachers in the same programme has been found to be beneficial for both groups; Jones and Eick (2007) report an initiative in which pre-service teachers, the majority of whom were studying science at university level, were able to contribute a high level of content knowledge to the planning and delivery of co-taught multimodal lessons with in-service teachers.

Peer learning and support

Learning from peers through co-teaching also has been identified as a powerful strategy for building competencies in multimodal teaching. In one project, student teachers worked with a group of three peers as co-teachers during real science and maths lessons in schools in half-day blocks (Leonard et. al., 2011). This experience was supported by peer internships taking place at weekends. Another initiative involved small peer groups of pre-service teachers in the planning and delivery of two-week long blocks of inquiry, with peer support facilitated through videotaping of lessons for the purposes of peer critique (Lotter et al., 2007). Peer projects can be supported effectively through the use of online discussion boards hosted in virtual learning environments (Lustick, 2009). Similarly, Spector et al. (2007) report asynchronous peer discussion on virtual learning environments supporting pre-service teachers to build their conceptions of multimodal teaching.

4 END-USERS REQUIREMENTS SURVEY

4.1 RESEARCH DESIGN

4.1.1 Data collection

The data collection process started by designing a questionnaire for eliciting teachers' beliefs, intentions and actions in using multimodality for teaching and learning. The VARK[2] for Teachers and Trainers questionnaire on multimodality practice has been adapted to encompass questions aligned towards identifying variation in teaching and learning strategies, digital technology, multimodal methods and approaches deployed by teachers in 3 European countries. In particular, 30 teachers in Germany, 20 in Finland and 18 in Denmark have completed the questionnaire. Purposing sampling techniques were used to serve the purpose of selecting school teachers from different disciplines. The questionnaire[3] has been replicated into 3 instances for the purpose of comparing the data between the three different countries. The questions designed were closed and semi-structured for allowing the possibility of selecting one (in certain types of questions) or more (in other types of questions) questions as to enable the participants to identify strategies and practices that characterises their experiences in using multimodality in learning and teaching. All questionnaires were in English except for the German participants where the questionnaire was translated in German as requested by AFBB for ensuring that all meanings and nuances are clear and understandable by the German teachers. The nature of the questions and their type has been informed by end-users' feedback and input. In particular the end-users provided input on questions that felt they should entail multiple choice questions (with only one correct answer) or checkboxes (checking options they felt that represented their practice). English phrasing issues were raised especially from end-users whose native language is not English.

The questionnaires were available online along with an information sheet illuminating the reasons of taking part on this research and the potential disadvantages and risks of that potentially could emerge. Confidentiality of data and results were explained in terms of future publications to high impact technology-enhanced learning journals and conferences. An informed consent form was then provided to the participants for agreeing to take part on this project and that all information provided will be treated in confidence. There was a wide range of topics taught by the participants ranging from sciences such as mathematics, physics and chemistry, to linguistics, computing, graphics design, entrepreneurship and mental health as presented in the following tables.

Table 2 AFBB subjects taught

AFBB	
Number of participants	Subject(s)
3	Pedagogy
3	Educational training, Training for nursery school teachers
3	Marketing, human resource management, communicational studies
3	Business administration/ Business English

[2] http://vark-learn.com/the-vark-questionnaire/teaching-questionnaire/

[3] https://docs.google.com/forms/d/e/1FAIpQLSdAmm_jiG75zCH4LpZWUTABfuv9Db3sp9bb5gougV2TdNVedw/viewform
https://docs.google.com/forms/d/e/1FAIpQLSdpwhogdbyRdvjnRGQFbyHtMjrpourxu5-u9plqYtNQW2MR0g/viewform
https://docs.google.com/forms/d/e/1FAIpQLSfEo4SxmVkHwT7IzhllR2W1j8Ek7M7EicVKxNnd4r8HVxiEQQ/viewform

2	Social pedagogical learning fields
1	Accounting, procurement
1	Anatomy, Care for the elderly
1	Music, guitar playing
1	History, civics education, business studies, law
1	German, Arts
1	Experiential education/ outdoor education
1	Safety Engineering
1	Logistics
1	Ergonomics and management systems
1	Maths, Statistics
1	Methods in the elderly care
1	Speech training
1	Company management

Table 3 SEDU subjects taught

SEDU	
Number of participants	Subject(s)
3	Entrepreneurship
2	Digital tools for learning
2	Maths
1	Information Technology
1	Graphic Design, Adobe software
1	Physics and Chemistry
1	Automotive Technology
1	International economy
1	Mental health, rehabilitation
1	English
1	Embedded systems and programming
1	Business and marketing
1	Design, visual arts
1	Finnish, communication, literature
1	Nursing and care, drug care, first aid
1	Clothing and textiles

Table 4 VUCSTOR subjects taught

VUCSTOR	
Number of participants	Subject(s)
10	Danish
8	English
6	Maths
1	Childhood Education
1	Science
1	Dyslexia
1	Social Sciences
1	History

4.1.2 Data analysis

Thematic analysis has been used as the overarching method for identifying, analysing and reporting patterns in the data from the survey. We have used thematic analysis on survey data with semi-closed, semi-structured questions and open questions for engaging into the process of discovering the themes embodied and dramatised in the evolving meanings of the data. We have followed Braun and Clarke (2006) recommendations of carrying out thematic analysis:

- Familiarise with the data
- Generate initial codes
- Search for themes
- Review themes
- Define and name themes
- Produce the report

Repeating this process for all data-sets gathered from the end-users, we categorised the data while considering connections and interconnections between codes and themes. On a second level we have made an attempt to adhere to the findings of the scoping study as to formulate evidence from theory. In the continue, we generated eight codings (e.g. Evidence in understanding and using Multimodality in teaching and learning, Technology for information transfer, Technology for collaborative learning, Serious games for teaching and learning multimodality) which were mainly emerged and resembled with the different sections of the survey. All the data were inserted into the Microsoft Excel software in order for graphs/charts to be generated and provide a clearer understanding and visualisation of the data. It is worth mentioning that a comparative approach to analyse the findings also emerged from the questionnaire. To facilitate this approach, clustered bars and columns were created for each question included in this survey. At the next stage of the analysis, the findings were cross-compared between and within the three institutions to draw a more complete insight of teachers' understanding and use of multimodality for teaching and learning. The identified similarities and differences are fully described, explained and presented in the next section.

4.2 RESULTS

4.2.1 Demographics

In total, 30 teachers from AFBB, 20 teachers from SEDU and 18 teachers from VUCSTOR completed successfully the online survey. This survey included three introductory sections with the presentation of the aim of the survey, an information sheet and an informed consent form. The aim of the fourth section was to collect demographic and background information about the participant-teachers. As presented in the Figure 4, the majority of the teachers who responded to this survey from all the institutions were females, while men appeared to be less (36.7% from AFBB, 40% from SEDU and 16.7% from VUCSTOR).

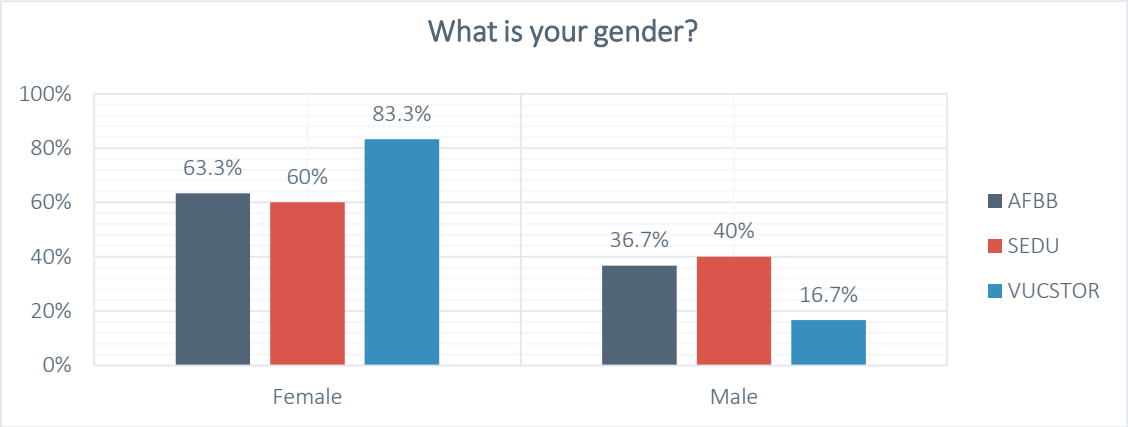

Figure 4 Teachers' gender

The majority of the participants who took part in this survey appeared to be middle-aged teachers. Specifically, the majority of the teachers from AFBB and VUCSTOR (50% and 44.4% respectively) were 35-44 years old, while the largest age group of the participants from SEDU (45%) were 45-54 years old. As shown in the Figure 5 below, less teachers were 25-34 years old (17% from AFBB, 20% from SEDU and only 11.1% from VUCSTOR) and 55-64 years old (17% from AFBB, 10% from SEDU and 16.7% from VUCSTOR). Finally, no participants were aged 18-24 years old from SEDU and VUCSTOR and only one participant from AFBB was 65-74 years old.

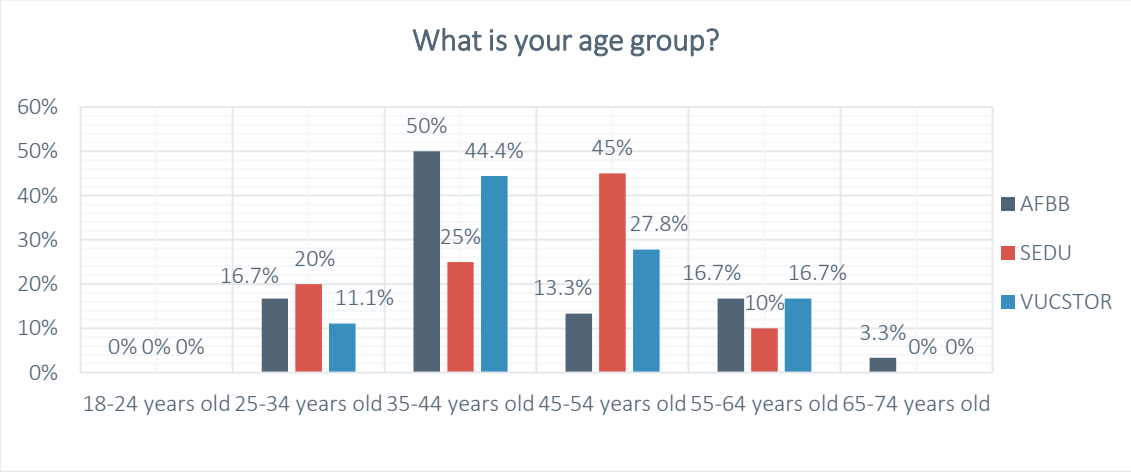

Figure 5 Teachers' age group

Next, the participants were asked to provide information about the age group of their students. The majority of the teachers from SEDU (60%) have the youngest students, aged between 16 and 18, while the two other institutions have just few teachers with students of this age group, as illustrated in the Figure 6. A significant proportion of the students of the respondent-teachers from VUCSTOR (66.6%) aged between 18 and 34 (44.4% of the students are 18-24 years old and 22.2 % are 25-34 years old). Finally, the majority of the teachers from AFBB (46.7%) teach students of all the age groups, a significant proportion of the teachers (26.7%) have students aged 18-24 years old, while just few of them have students of the other age groups.

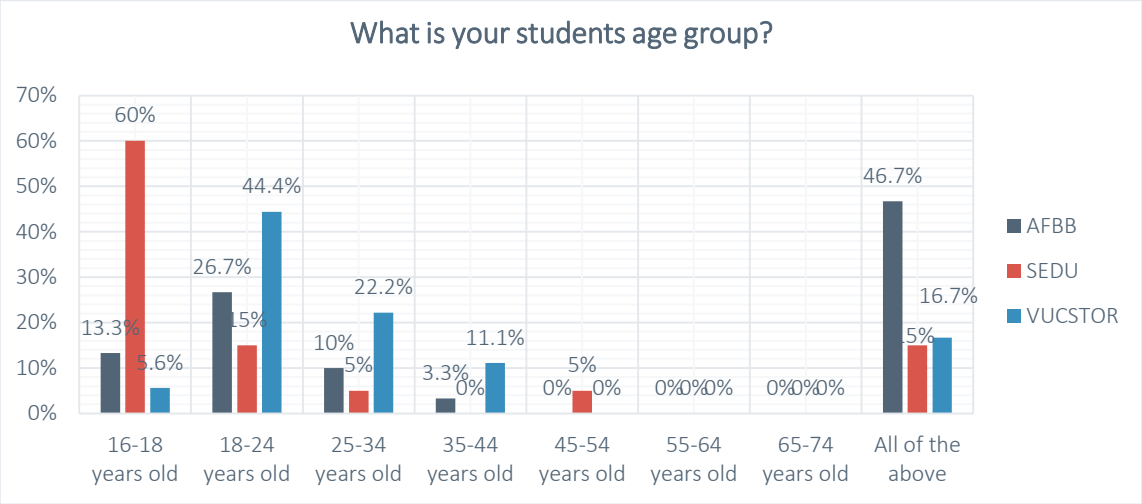

Figure 6 Students' age group

The participants provided a wide range of answers concerning the topics they teach. Specifically, overall 21 participants from all the institutions teach literature (English, German, Danish or Finnish), 9 participants teach education-related subjects such as pedagogy, social pedagogical learning, experiential education, training for nursery school teachers and Childhood Education. Moreover, popular subjects were also Maths (8 participants) and Business and Marketing (6 participants). Other subjects which the teachers of the survey teach include but are not limited to history, arts, science, chemistry, Information Technology, music and visual arts. Moreover, the teachers were enquired "What topics do their teacher-students teach. The vast majority of the teachers from AFBB (29 out of 30) answered that they do not have teacher-students. It was only one participant who provided the answer, nursery school teacher. Only four participants from SEDU answer that the topics their teacher-students teach are Business Economics, Digital teaching methods, Entrepreneurship and different topics, while only two participants from VUCSTOR answered that they tech Kindergarten nursing and Maths.

Finally, the teachers were asked to provide the highest educational level they have completed. Interestingly, the vast majority of the teachers from AFBB (74.1%) and SEDU (70%) have completed a Masters' degree, while only the 5.6% of the teachers from VUCSTOR have obtained a Masters. The majority of the teachers from VUCSTOR (66.7%) have completed a Bachelors' degree while at the same time the 25% of the teachers from SEDU and only the 3% from AFBB have obtained a Bachelors' degree. As demonstrated in the figure below, just few of the participants from all the institutions reported that the highest level of the Education they have received is Vocational training, Educational Certificates, PhD or other kind of education while only one participant from VUCSTOR has as a highest level of Education the Secondary school.

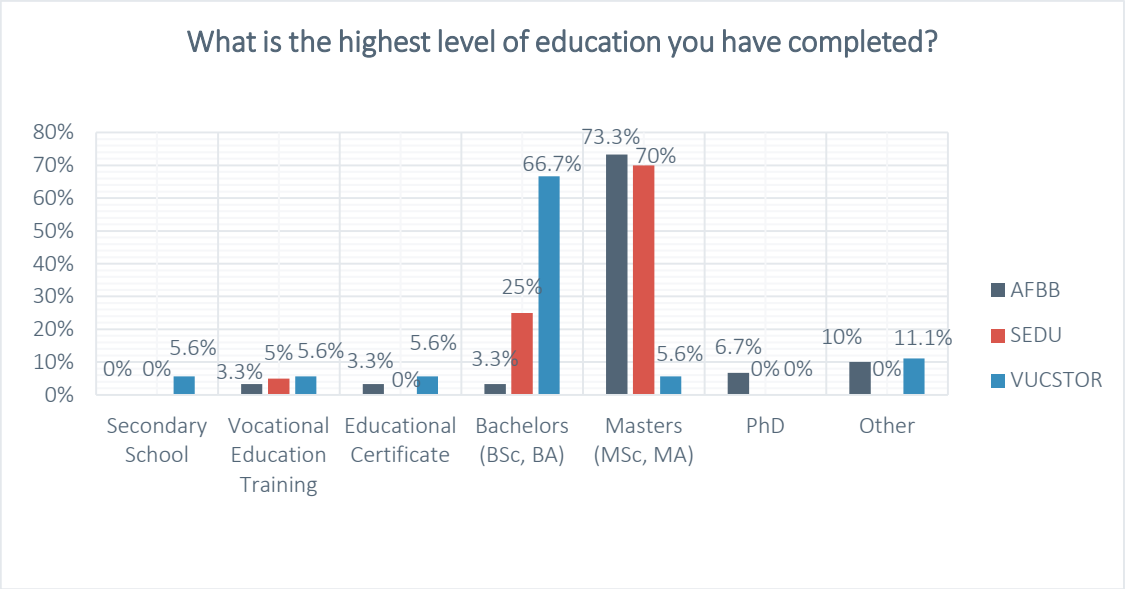

Figure 7 The highest level of education of surveyed teachers

4.2.2 Evidence in understanding and using Multimodality in teaching and learning

The aim of the fifth section of this survey was to collect information about the participants' understanding and use of technologies for multimodality in their teaching and learning practices. The participants were asked to give a definition of multimodality for teaching and learning. The answers revealed that in their majority the teachers from the three surveyed institutions have a clear understanding of what multimodality is and in line with the contemporary definitions revised in the literature. Specifically, most of the participants from AFBB (53.3%) and SEDU (50%) define multimodality as "a complex of modes including talk, visual communication, action, gesture, posture and movement". A considerable proportion of the teachers (43.3% from AFBB, 40% from SEDU and 33.3% from VUCSTOR) believes that multimodality describes communication practices using modes to develop and deliver content. Another definition chosen by several participants, particularly from teachers from VUCSTOR (38.9%) defines multimodality as the processing of information through multiple modalities. Significantly less participants (16.7% from AFBB, 15% from SEDU and 16.7%) perceive multimodality as computer software and multimedia, while only one participant from AFBB and VUCSTOR as Print-based reading and writing, which reveals that these teachers have not a concrete and complete understanding of multimodality. It is also worth mentioning that an important proportion of the participants (30% from AFBB, 35% from SEDU and the majority of the teachers from VUCSTOR-38.9%) chose as the definition of multimodality the answer which combines all of the above definitions, showing a complete understanding of what multimodality is.

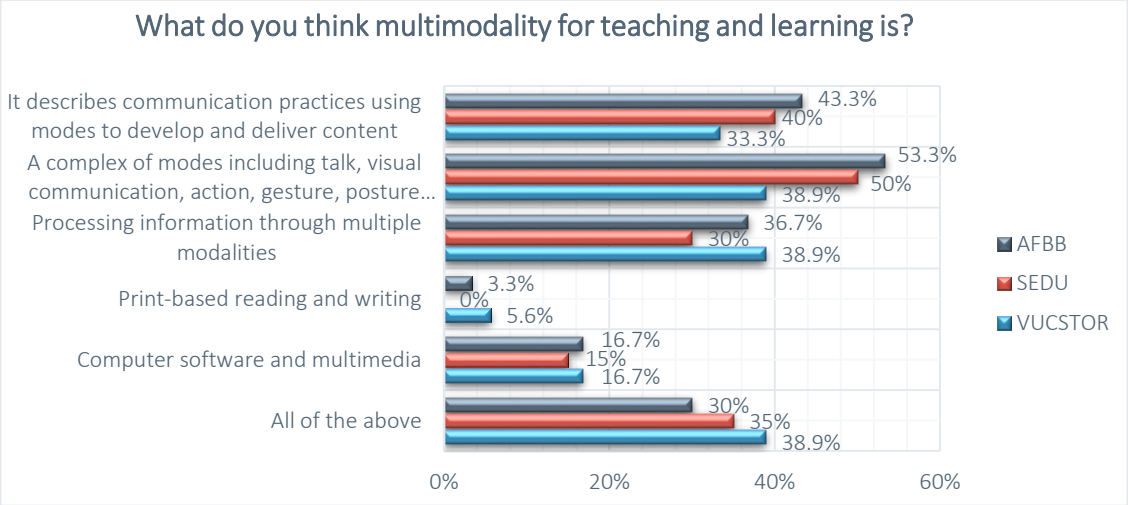

Figure 8 Teachers' definition of multimodality for teaching and learning

The participants were asked to provide their feedback concerning the extent to which they use technologies (e.g. computers, mobile devices and whiteboards) for enhancing multimodality in learning and teaching. Overall, all the surveyed participants reported that they use technologies for enhancing multimodality in teaching and learning. Specifically, the majority of the participants from AFBB and VUCSTOR (40% and 50% respectively) indicated that they use extensively technologies in their teaching and learning strategies. The majority of the teachers from SEDU (45%) demonstrated that they use quite a lot technologies for promoting multimodal teaching and learning, while at the same time many participants from the same institution reported that they use technologies extensively. Therefore, it is evident that novel technologies are viewed by educators as means of enhancing multimodal teaching and learning practices and in this way reinforce students' engagement and learning experience. However, as shown in the Figure 9 below, there were also participants from the three surveyed institutions and mostly from AFBB (36.7%) that they only use technologies sometimes in their practices. Those educators have not incorporated actively technologies in their

teaching and learning possibly because they are not familiar with technologies, they might have not received sufficient training so that they can support multimodal teaching and learning strategies using digital technologies or they possibly adopt more traditional and paper-based teacher-centred practices.

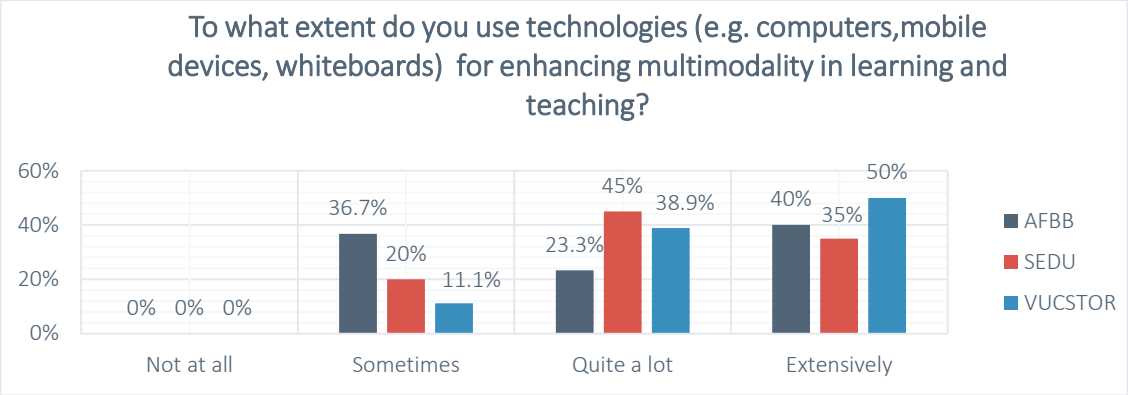

Figure 9 The extent to which teachers use technologies for enhancing multimodality

Finally, in this section, the participants were asked to provide the reason why they use new technologies for enhancing multimodality in their course. Overall, the majority of the participants (43.3% from AFBB, 55% from SEDU and 50% from VUCSTOR) as illustrated in the Figure 10 below, indicated that they use technology for both transferring information and content and for enhancing dialogue, collaboration and support. This response illustrates that many teachers perceive technology as a mediational tool with multimodal affordances that can facilitate not only the preparation and presentation of more traditional-based practices and resources (e.g. transferring of information) in a more interactive way than before but also the enhancement of more student-centred approaches with the aim to promote collaboration and create a more dialogic and supportive learning culture. There is also a considerable amount of teachers from all the surveyed institutions and especially from VUCSTOR (50%) that perceive technologies as tools for enhancing only collaborative practices, dialogues and (peer) support, using in this way multimodal technologies to promote student-centred practices, exchange of ideas, communication and scaffolding learning. On the other hand, it is also noticeable that there are educators (e.g. 23.3% from AFBB, 15% from SEDU) who use the multimodal affordances of technologies in order to promote only the transferring of information and content. This result reveals that there are teachers who perceive technology as a mean to facilitate their traditional practices by using a set of new tools and rich-mediated semiotic resources in order to make their teaching more interesting and interactive.

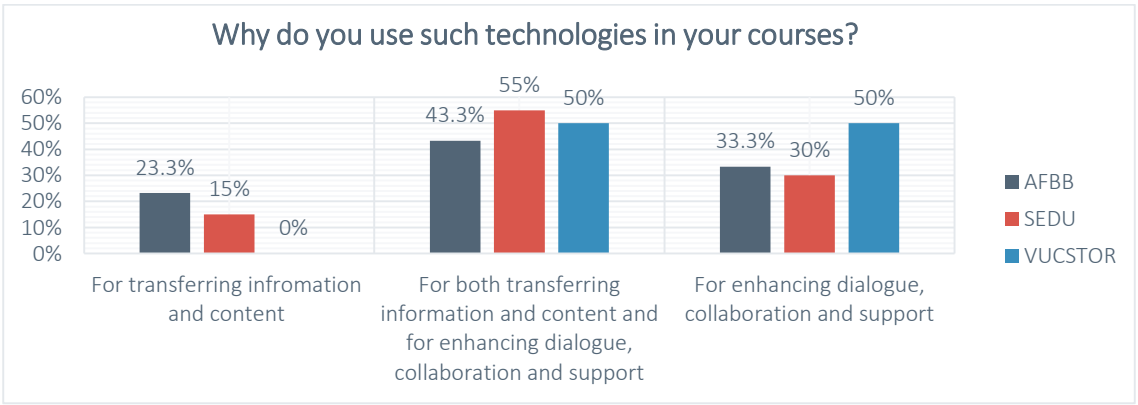

Figure 10 The reasons why the teachers use technologies for teaching and learning

4.2.3 Technology for information transfer

The aim of the sixth section was to identify how teachers use technology for information transfer. All the participants from SEDU and VUCSTOR and the 90% of the participants from AFBB reported that they use technology for information transfer. Only 3 participants from AFBB do not use technology at all for information transfer. This result illustrates the importance of technology for resourcing the traditional-based practices of transmission and memorisation using a variety of modalities in order to engage students and reduce their cognitive load. It was observed that even if several participants had reported that they use technology only to enhance multimodal collaborative practices (see Figure 10 above), in this question they answered that they use technology for information transfer. This result reveals that a number of educators inform their collaborative tasks with elements of teacher-centred practices by using for example technologies to facilitate well-structured collaborative tasks providing detailed instructions, directions, additional information and support.

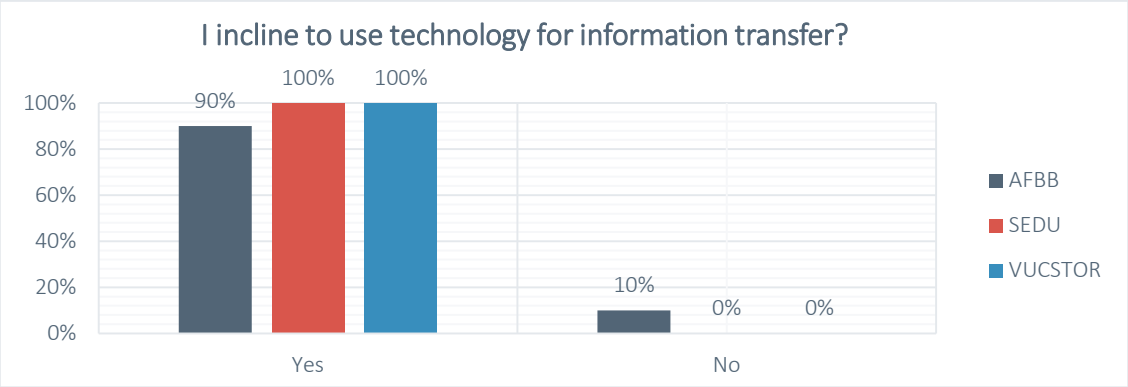

Figure 11 The use of technology for information transfer

The participants who responded positively to the question above, were also asked to specify what modalities they use for information transfer in their teaching and learning practices. The participants at this type of question had the opportunity to provide more than a single answer. The answers given by the participants from the different institutions varied possibly due to the different educational systems and the practices that are promoted in each country. Overall, the most popular modalities that teachers use for information transfer are the PowerPoint presentations, the notification boards and the web-pages which reveals the power that multimodal technologies have in enhancing the presentation and memorisation of information and knowledge. Specifically, all the teachers from AFBB reported that they use notification boards, in their vast majority (92.6%) they use oral descriptions of the topic for students to memorise, written hangouts (88.9%) and summative assessment and PowerPoint presentations (70.4%). In contrast to the teachers from AFBB (33.3%) who seem not to actively use web-pages/repository for storing content, the teachers from both SEDU and VUCSTOR, value the use of web-pages in their teaching and learning (75% and 77.8% respectively). Moreover, similarly to the teachers from AFBB, an important percentage of the teachers from the other two institutions as illustrated in the Figure 12 use PowerPoint presentations in their teaching. This might reveal that teachers use multimodal technologies which are more user-friendly and possibly familiar to them for information transfer rather than for the promotion of student centeredness. Notification boards and summative assessment are modalities that are used from approximately the half of the participants from SEDU and VUCSTOR. Therefore, it has been seen that even if the use of the multimodal technologies is viewed from the perspective of the information transfer which is based on more traditional teacher-directed approaches of teaching and learning, the teachers possibly aim to open up a new window to this transmitting knowledge practice and support students' attempts to think, retain or even construct ideas and views by providing the information (given before either orally or in a written form) using a variety of different modalities.

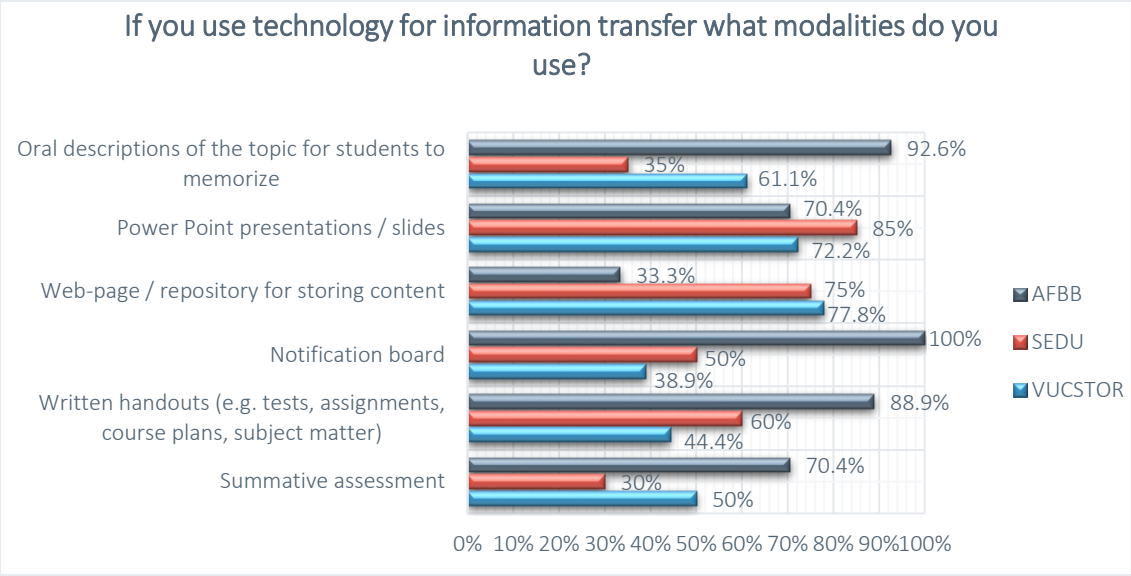

Figure 12 Modalities used by teachers for information transfer

4.2.4 Technology for collaborative learning

The aim of the seventh section of the survey was to identify how teachers use technology to promote collaborative learning practices. The vast majority of the surveyed teachers from SEDU and VUCSTOR (95% and 100% respectively) indicated that they use technology for collaborative learning practices. On the other hand, the majority of the teachers from AFBB reported that they do not use technology for collaborative learning. However, at the same time a considerable amount of the AFBB's teachers (43.3%) as illustrated in the Figure 13 uses technology to facilitate their collaborative practices. This result shows that the use of collaborative practices mediated by multimodal technologies is rapidly growing and more and more teachers are confident in integrating them into their classrooms. Teachers believe that the combination of multimedia content with collaborative learning practices might lead to engaging, powerful and interactive multimedia collaborative learning environments. However, as revealed by the AFBB teachers' contribution to this question, there are still several teachers who are a bit reluctant in integrating novel and more student-centred pedagogies. This might be due to the country's or institution's focus on particular teaching and learning methods or even due to the teachers' limited knowledge and training on how to use multimodal technologies for enhancing collaboration between students.

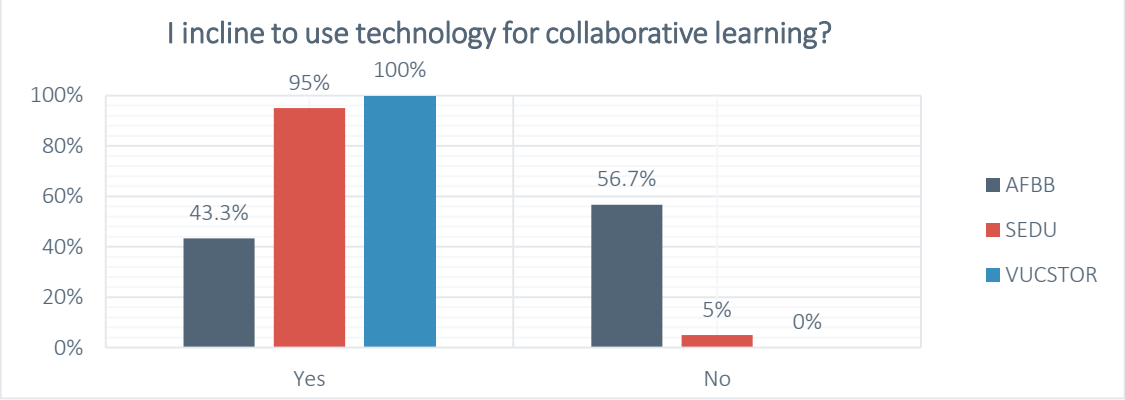

Figure 13 The use of technology for collaborative learning

The participants who responded positively to the question above, were also asked to specify what modalities they use in order to enhance collaborative learning practices. Collectively the data show that the use of collaborative projects mediated by multimodal technologies was the most prominent choice between the others for the teachers from the three surveyed institutions (76.9% from AFBB, 84.2% from SEDU and 72.2% from VUCSTOR). Beyond this option, formative assessment seemed to be an important part of teaching and learning strategies used by teachers from AFBB (61.5%), while the use of other modalities including blogs, Podcasts (23.1%) and Social networking (15.4%) are not widely used to promote co-construction of knowledge. On the other hand, interestingly, the teachers from SEDU appeared to use a variety of digital modalities to enhance collaboration. As illustrated in the Figure 14 below for example, 68.4% of the use synchronous, asynchronous discussion tools and Social networking tools and 57.9% use collaboration authoring tools. A possible explanation for this could be that the teachers use a set of digital tools and modalities as part(s) of bigger collaborative projects, enriching and widening students' communication, sharing of ideas as well as offering scaffolding learning opportunities. Similarly, the teachers from VUCSTOR prefer to use a variety of multimodal collaborative tools and practices (e.g. collaboration authoring tools, formative assessment, synchronous and asynchronous discussion tools).

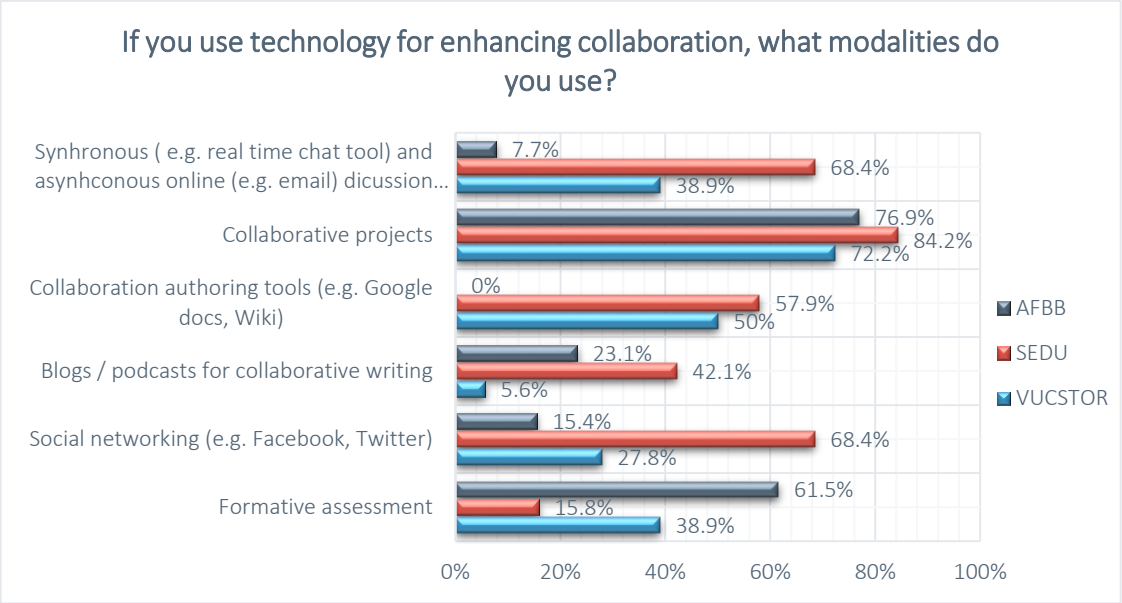

Figure 14 Modalities used by teachers for collaborative learning

4.2.5 Deployment of strategies for multimodality for different modes of teaching and learning

The aim of this section was to gather the strategies that teachers deploy for multimodality for different models of teaching and learning practice. The participants in the beginning of this section were enquired about what modes of meaning they present to their students. Collectively the data of this survey show that the dominant modes of meaning chosen by the participant-teachers to present to their students are the written (86.7% from AFBB, 85% from SEDU and 61.1% from VUCSTOR) and the oral language (80% from AFBB, 85% from SEDU and 61.1% from VUCSTOR). These data reveal that even if the participants appeared to have a good understanding of what multimodality is and that novel forms of modes and resources are emerged; in their personal practices in their majority, they still prefer the ones used in more traditional classrooms as revised in the literature. As shown in this survey (see Figure 15), the audio and gestural representations are also modes used by many teachers in their practice. Notably, the majority of the teachers from VUCSTOR (66.7%) use audio representation. Moreover, the least preferable modes of meaning seemed to be the spatial and tactile representations. Finally, interestingly, a considerable proportion of the teachers from VUCSTOR (33.3%) but only few from AFBB (20%) and SEDU (10%) use multiple representations of contents (e.g. texts, images, videos, audio, pervasive media) promoting multimodal teaching and learning strategies in their classrooms.

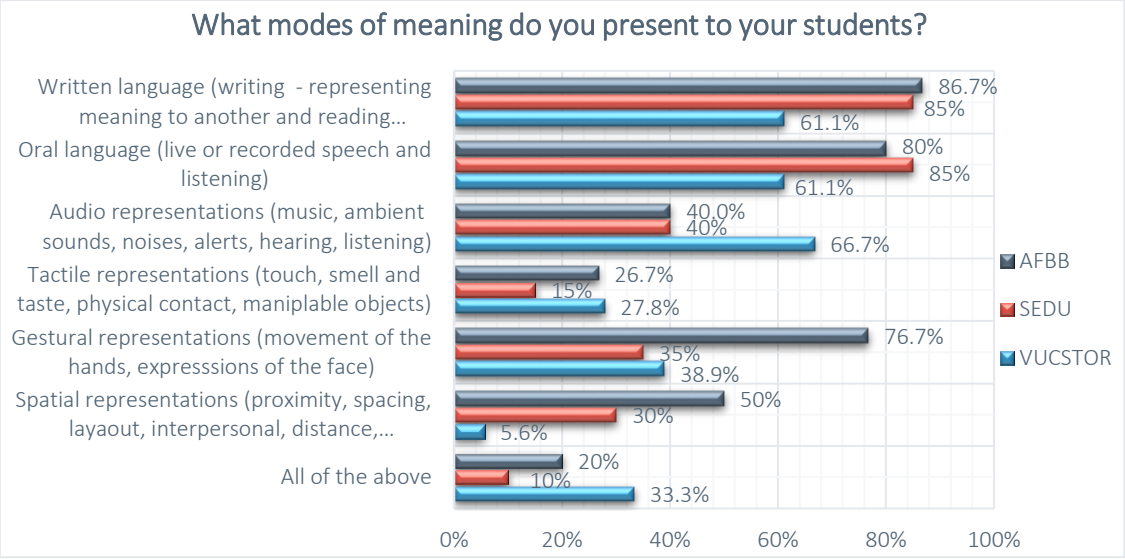

Figure 15 The preferred by teachers modes of meaning for teaching and learning

The participants were also enquired about what strategies they use for enabling their students to learn in different ways. The majority of the participants-teachers (86.7% from AFBB, 60% from SEDU and 55.6% from VUCSTOR) reported that the encouragement of collaboration by assigning group activities for visualising important events and compare data is the most prominent strategy they use. This illustrates that the teachers value the multimodal affordances of new technologies to promote more collaborative-based strategies of teaching and learning. However, at the same time, a significant number of the participants from AFBB (86.7%), 40% from SEDU and only 22.2% from VUCSTOR indicated that the strategy of transferring information for students to memorise is also a really important strategy for them, showing that the more traditional-based practices are still powerful and influential in the classroom settings and educators' practices, however, enriched by multiple and novel modes of representations. The development of information literacy skills by asking students to search, find and retrieve information on the Web was also one of the most popular strategies used by teachers (66.7% from AFBB, 75% from SEDU and 55.6% from VUCSTOR). A possible explanation for this, could be that teachers aim to engage their students actively with a wide range of scientific

information resources via their involvement in independent or guided information gathering, evaluation, analysis and synthesis and in this way promoting multimodal information literacy. This strategy might also reveal the shift of students from passive audience to editors of meaning, researchers, writers and interpreters which is in line with the literature (Miller and McVee, 2013). The encouragement of the students to talk about their learning by using blogs, online discussion threads and live discussions was also one of the strategies that many of the surveyed teachers prefer in their practice. This strategy shows that teachers perceive multimodal technologies as appropriate tools which reinforce students' communication, permitting them to reflect on their experiences, monitor their learning and share it with their peers and/or teacher.

Less popular strategies among the aforementioned as demonstrated in the Figure 16 were the i) guidance of student's reflection process via the use of a blog, wiki or podcast, ii) help of students to apply their knowledge to real-world situations represented in games and virtual experiments and virtual worlds and iii) promotion of creativity by encouraging students to create visuals such as characters, digital stories and games. These findings might indicate that even if in the literature the students have been increasingly seen as creators rather than consumers of the digital products by using a variety of software to create multimedia presentations, simulations, websites, virtual words, the teachers (Mills, 2010), in practice the teachers do not perceive it as one of their priorities. Notably, none of the participants reported that they use a blend of the given choices-strategies. This reveals that the teachers have not incorporated massively into their learning strategies the experiential learning, the creation-production of artefacts by students (individually or collaboratively) as well as the reflective learning practices.

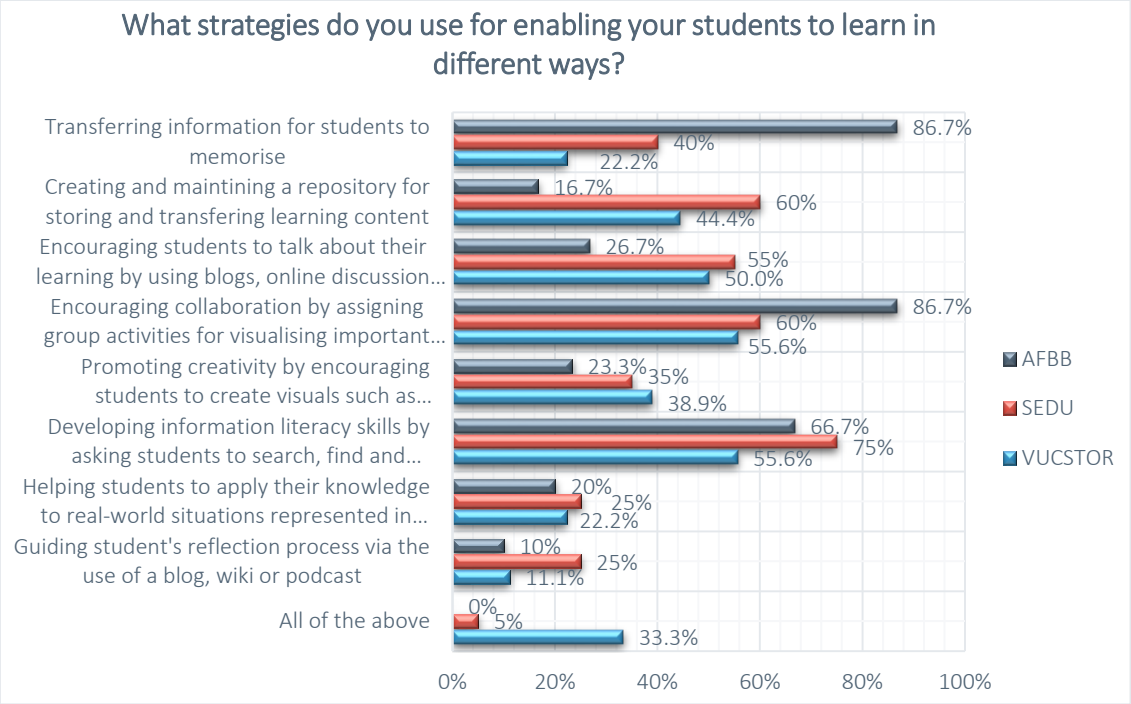

Figure 16 Strategies used by teachers for enabling their students to learn in different ways

In the next question, the participants were asked to provide their feedback concerning the way which they sustain learning in many modes beyond face-to-face teaching. The most popular ways reported by the teachers were inspired by more teacher-centred approaches via the use of multimodal technologies. The majority of the teachers prefer to store learning content on the LMS/web and they ask their student to learn it (36.7% from AFBB, 55% from SEDU and 61.1% from VUCSTOR). This shows that teachers value the use of digital media to create and modify content using a blend of modes and

make it available online to their students beyond the classroom walls, however with the purpose to transmit knowledge and information rather than promoting the active production of artefacts by the students. An important proportion of the teachers also prepare online quizzes and tests for assessing students' knowledge (20% from AFBB, 45% from SEDU and the majority of the teachers from VUCSTOR, 77.8%). This finding illustrates that teachers continue to use more traditional-based summative assessment based on quantitate measurement of student performance (Kalantzis and Cope, 2010) by using new digital and multimodal means rather than paper-based tests. The use of collaborative authoring tools (Google docs) by students / student groups for carrying out a project (40% from AFBB, 45% from SEDU and 50% from VUCSTOR) was also one of the popular strategies used by the teachers. A possible explanation could be that teachers perceive multimodal technologies and their affordances as valuable means for supporting collaborative learning tasks which allow students to combine traditional writing pedagogy, multimodal expression and online interaction with their peers.

According to the results of this survey, less popular strategies used by teachers were i) the organisation of Web searches and information retrievals in an online portfolio by the students, ii) the preparation of online discussion threads on a subject topic, asking from students to provide their thoughts via the Learning Management System (LMS) and ii) the preparation of live videos broadcasts of the lesson for students to attend from home. These findings might show that teachers are not confident enough in developing and supporting more complex multimodal resources and learning activities possibly due to limited training opportunities and their difficulty in changing or adapting their own practices.

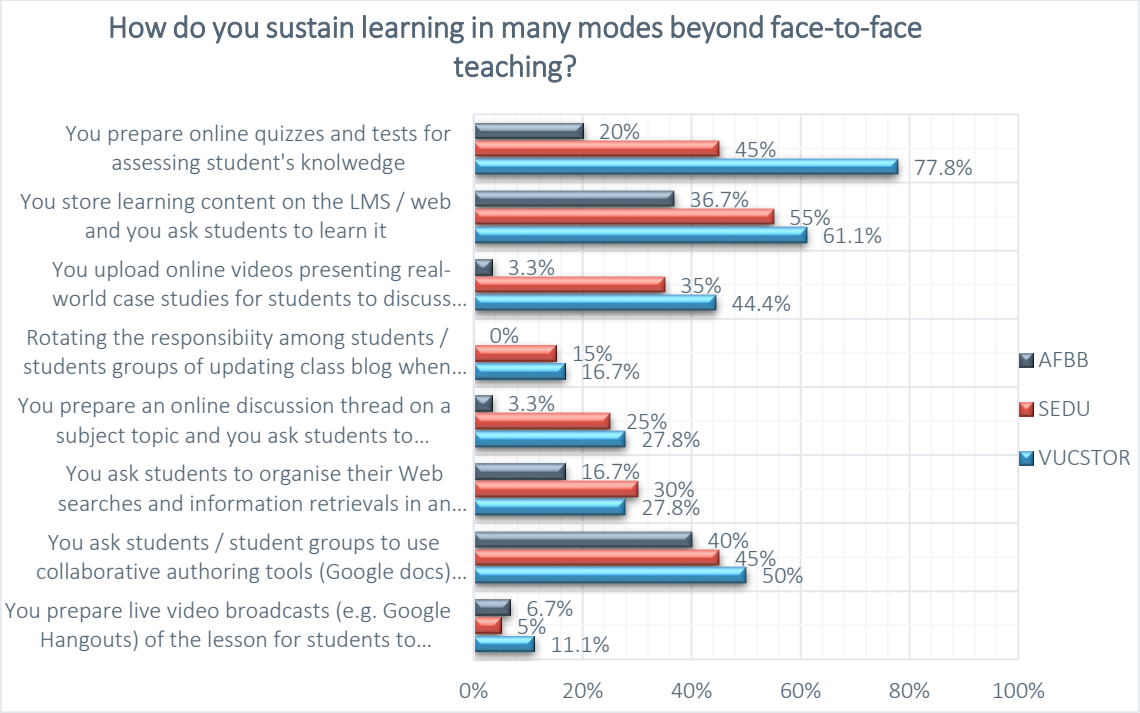

Figure 17 The ways which teachers sustain the learning process in different modes beyond face-to-face teaching

4.2.6 Teaching and learning strategies for integrating multimodality

In the next thematic section, the participants were asked to provide their feedback concerning the strategies they would prefer to use in specific teaching and learning situations. Specifically, the first of this type of questions enquired the way which the teachers would ideally prepare the first ten minutes of a learning session of their course for their students. The majority of the respondents from AFBB (46.7%) prefer to introduce their session by an oral statement that stresses what students need to learn, absorb and memorise, illustrating their preference in more traditional-based approaches via the use of the predominant oral communication modes. This approach also shows that less emphasis is given to the students' ideas and interests but mainly on teacher's organisation of content-based sessions and activities. On the other, hand, the encouragement of students to collaboratively brainstorm on what they want to learn in this course via a Google docs was the most popular option of the educators from SEDU and VUCSTOR (45% AND 38.9% respectively). This approach highlights the importance of students placed in the centre of learning, their personal interests and prior knowledge as well as their interaction with peers and the collective development of ideas exemplifying a student-centred approach guided from the teacher.

A considerable amount of participants from AFBB (30%) and VUCSTOR (38.9%) but only 15% of the teachers from SEDU would ideally use a power point presentation showing examples and applications of how aspects of the course are beneficial for the society. This approach might demonstrate the utilisation of more familiar to the teachers multimodal tools with the aim to promote a more visual and interactive way of learning and teaching than before (sole mode of oral presentation and communication). On the other hand, the provision of explanation to students through visual diagrams for highlighting the importance of the course and the connection between topics was significantly less popular as an option (6.7% from AFBB, 15% from SEDU and 16.7% from VUCSTOR). This possibly reveals that teachers meet difficulties in creating novel and more complex multimodal artefacts in order to introduce a session. The choice of referencing students to read the outline of the course available on the LMS was also less attractive to the teachers.

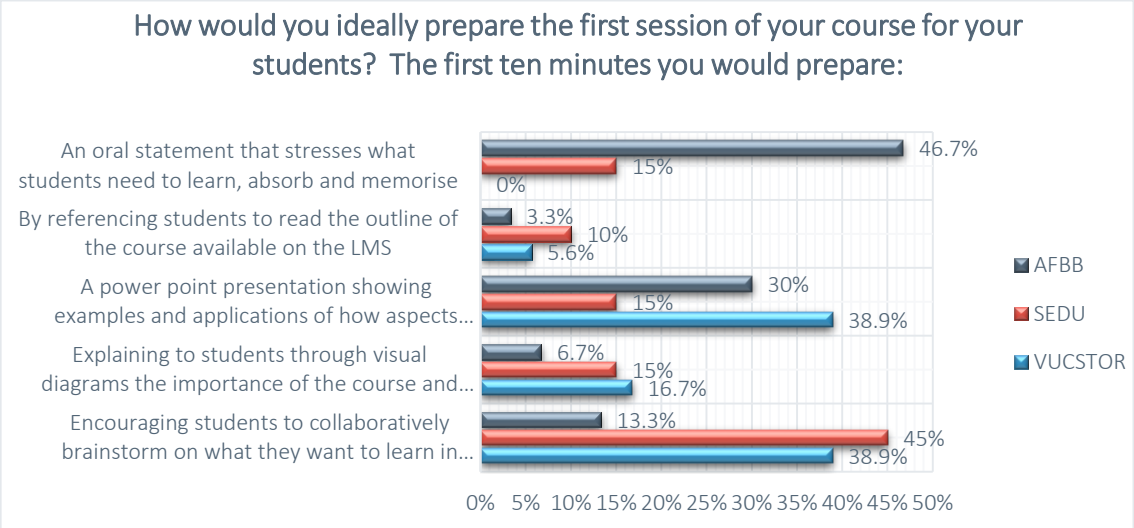

Figure 18 The first ten minutes preparation choices by the teachers for the first session of their course

In the next question, the participants were asked to provide their response concerning how they would ideally help their students to do a comparison between two concepts. The majority of the participants from AFBB (36.7%) and VUCSTOR (38.9%) would choose to show a video to their students for understanding how the concepts are practiced in real-life. This reveals that teachers value the audio-visual modes of video compared to the sole modes of representation such as only visuals, audio

or more traditional oral communication mode. The majority of the teachers from SEDU (35%) but also several teacher from AFBB and VUCSTOR, would ask the students to find online resources about the concepts and present their finding on their blogs. Thus, considerable attention is being centred to a constructivist-based approach and is based on the individual or collaborative web searching, allowing the students to explore, investigate and develop ideas. The approach of using an oral description for defining the two concepts for students to memorise was chosen by a smaller number of teachers, showing the preference of several teachers to use the oral communication as a mean to provide explanations to their students. Finally, one of the less preferred choices was also the use of an interactive visual representation (e.g. simulation, virtual experiment) for manipulating values.

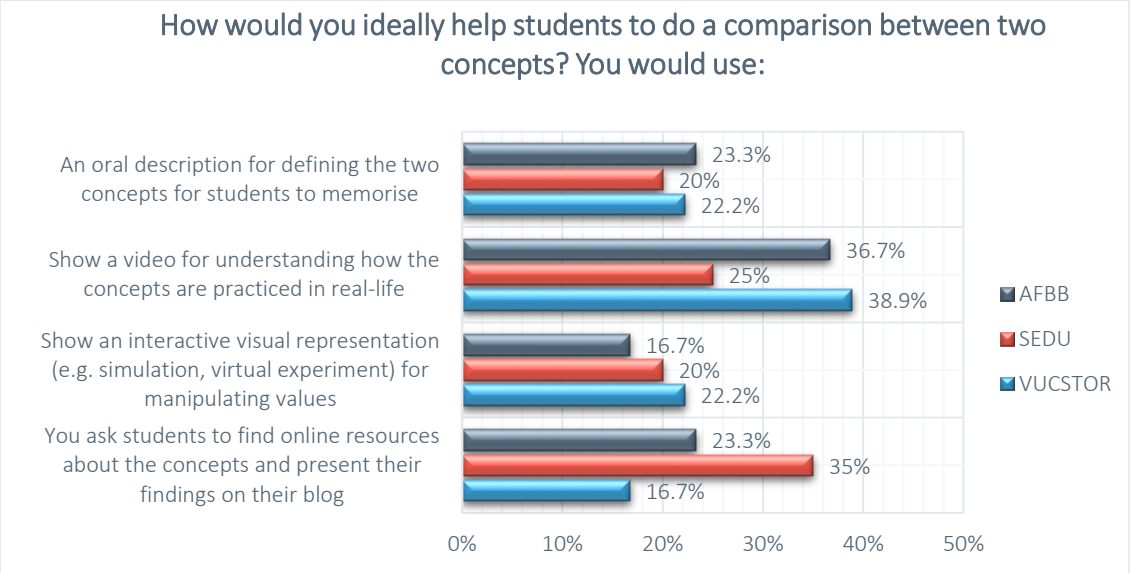

Figure 19 Strategies used by teachers for helping students to do a comparison between two concepts

The next teaching and learning situation that the teachers were asked to provide their feedback on, was the way which they would ideally set up a task in which the students would be required to create something as a team/group. The most of the participants from AFBB (66.7%) and just few from the other institutions (10% from SEDU and 27.3% from VUCSTOR) would provide a written assignment on a paper and ask students to submit it on time. This illustrates that more traditional-based practices which are emphasised on the written communication for the creation of an assignment are preferred by many teachers, however, excluding the multiple modes of representation. On the other hand, the sharing of the assignment with the students via Google Drive in order to provide their input based on their own interests was the most popular option for the teachers from SEDU and a significant proportion of the teachers from VUCSTOR (27.3%). This result shows that teachers support the online interaction and sharing of ideas between the members of the team, allowing them to exchange their interests and points of view using multimodal representations.

The provision of detailed visual representations of the steps needed to complete the assignment was chosen by a great proportion of the teachers from SEDU and VUCSTOR (35% and 36.4% respectively), illustrating their preference on the visuals rather than written mean of representation that the majority of the teachers prefer either when using or not technologies. Finally, the option of the preparation of a detailed assignment description along with a grade rubric on a Word file accessible via the LMS was the least preferable by the teachers overall. This result reveals that the use of technology as a mean to replace the written paper-based format of a collaborative task has not been seen as fertile as the more traditional modes of representation (e.g. the written assignment on a paper described above).

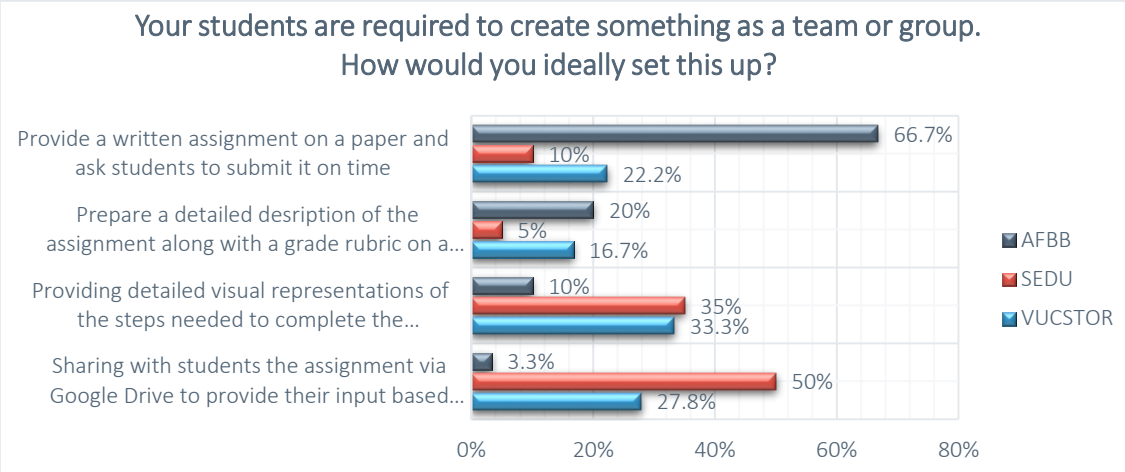

Figure 20 Strategies used by teachers for setting up a group activity

In the next question, the participants were asked to respond how they would approach if their students need a clarification on a question they have about a certain topic. In a similar way to this answered in the first question of this section, the majority of the participants from AFBB (53.3%) and VUCSTOR (38.9%) illustrated their preference in providing orally an answer to their students, without allowing them to do any follow-ups, adopting in this way a more traditional-based approach and using only one modality, the oral communication. On the other hand, the provision of visual representations (e.g. diagrams, videos) to stimulate student's understanding was chosen by a significant proportion of the teachers (40% from AFBB, 35% from SEDU and 33.3% from VUCSTOR). This preference of the teachers demonstrated the power of visual mean of communication in their teaching and learning practices.

Several teachers from SEDU and VUCSTOR (30% and 22.2% respectively) also showed their preference in uploading the question on the online forum for students to express their own ideas and negotiate with the teachers and their peers, illustrating their collaborative and dialogic practices. The least popular choice was the provision of the answer in a written form and uploading it to the class blog / online forum. This might reveal that teachers wish to give a more instant response to their students' queries orally, visually or using a combination of these two modalities, without waiting to upload their answers online or by promoting online discussion and negotiation among their students.

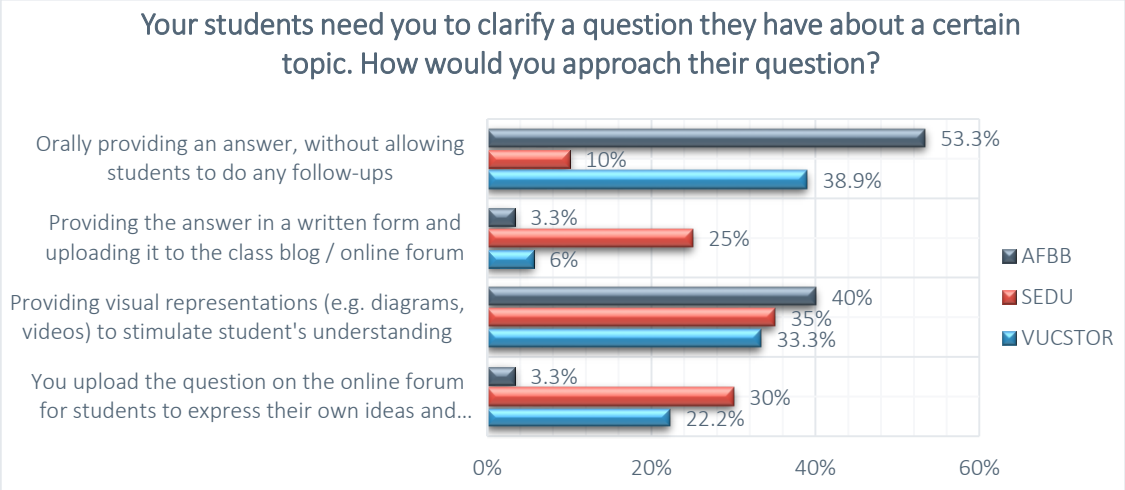

Figure 21 Strategies used by teachers for clarifying a question their students have about a specific topic

The participants enquired how they would provide their feedback to their students about their performance in tests. The vast majority of the participants from AFBB (73.3%) responded that they would jot down the score and grade for each student test paper. On the other hand, the majority of the teachers from SEDU and many teachers from VUCSTOR (60% and 50% respectively) participants would prefer the initiation of a discussion about what the students found easy and what difficult in the test, promoting a more dialogic strategy. The oral announcement of the grade to each individual student was also one of the options chosen by many teachers from the three institutions as demonstrated in the Figure 22 below. The least preferable options chosen by the participants of this survey were i) the visualisation of the results via the creation of a graph which depicts in a rich-mediated way the class performance, ii) the online provision of feedback by making available on the LMS a sheet with the correct questions and iii) the setting up of an online discussion thread with each student for personalised guidance and support.

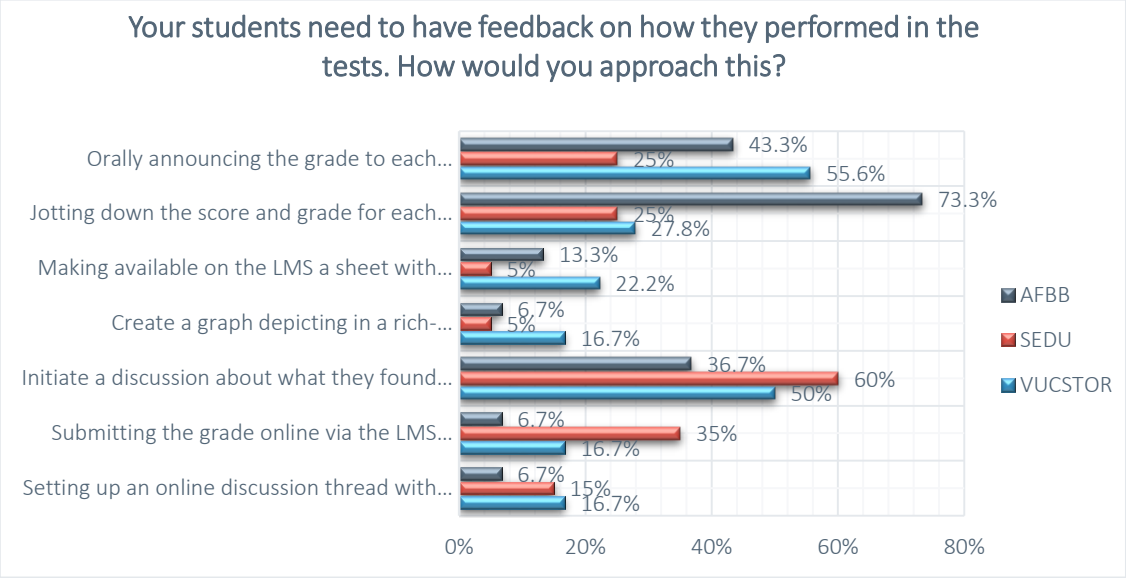

Figure 22 Strategies used by teachers for providing feedback about students' performance in the tests

Finally, the last teaching and learning situation which the participants were asked to provide an answer concerned the way they would prepare their students if they had organised a field trip for their students to explore a topic in question. As reported in the literature, the success of multimodal learning depends on how successfully and creatively will a teacher design activities that take place in spaces that enable students to develop real-world experiences (Falk and Storksdierk, 2005). Therefore, it is really important the way that they will set up and resource informal learning situations. The majority of the teachers from all the institutions (63.3% from AFBB, 50% from SEDU and 61.1% from VUCSTOR) indicated their preference in giving the initiation to their students to design their own field trip preparation guides. This result reveals that the teachers value and consider the students' ideas and interests adopting a student-centred strategy.

The provision of different web links of how to prepare for a field trip was also a common choice by many teachers for the teachers from SEDU and VUCSTOR (55% and 50% respectively), illustrating the power of technologies in informing students about a specific topic. However, the oral mean of communication remains at this learning situation one of the prominent strategies as well, as many teachers stated that they would orally describe the preparation that needs to be made by the students. Less popular choices were comprised of students using online tools and representations in different modes. The preparation and uploading of an analytical guide with preparation instructions by

the participants and the creation of a question and answer online session consist two examples of these less preferable options.

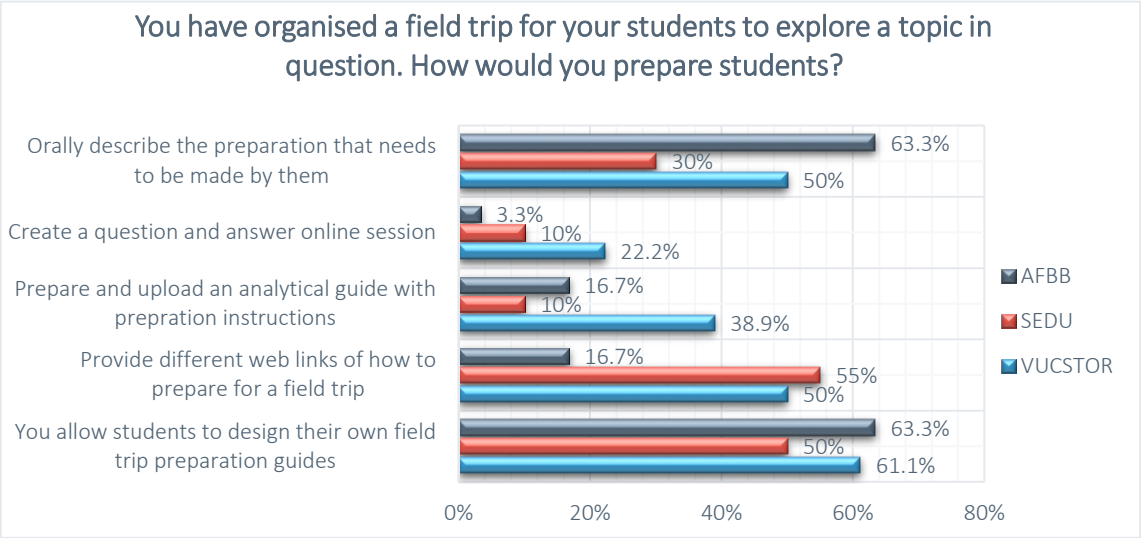

Figure 23 Strategies used by teachers for the preparation and exploration of a specific topic during a field trip

4.2.7 Modes of learning to use multimodality

The participants were asked to provide their feedback concerning the modalities they use for learning teaching and training. In this question the participants were able to provide more than a single answer. The vast majority of the participants reported that they use written text, images and handouts (96.7% from AFBB, 80% from SEDU and 61.1% from VUCSTOR). These results might show that they mainly use the aforementioned modalities in different ways, for example many teachers use Power Point for providing rich interactive descriptions (73.3% from AFBB, 65% from SEDU and 50% from VUCSTOR) or the LMS for storing content, assessing students and providing online feedback. Interestingly, a large proportion of the teachers (e.g. 70% from AFBB and 50% from VUCSTOR) stated that they incorporate games into the learning process for increasing their students' motivation, engagement and deep learning, illustrating that a variety of novel technologies have started to be incorporated into classrooms. However, the games are possibly used for information transfer without involving the students' active learning, exchange of ideas or creation of artefacts, given that many teachers especially from AFBB are focused on more information transmitting models of teaching and learning. Finally, the use of mobile applications (e.g. Socrative voting system, social media) for conducting short quizzes and tracking student activity in real time seemed to be one of the less popular options for teachers especially from AFBB (6.7%) as they require more active participation from the students and more collaborative learning approach of teaching and learning. However, there are teachers (50% from SEDU and 61.1% from VUCSTOR) that appreciate the students' interaction with more multimodal and social in nature tools and have started to use them more and more in their practices.

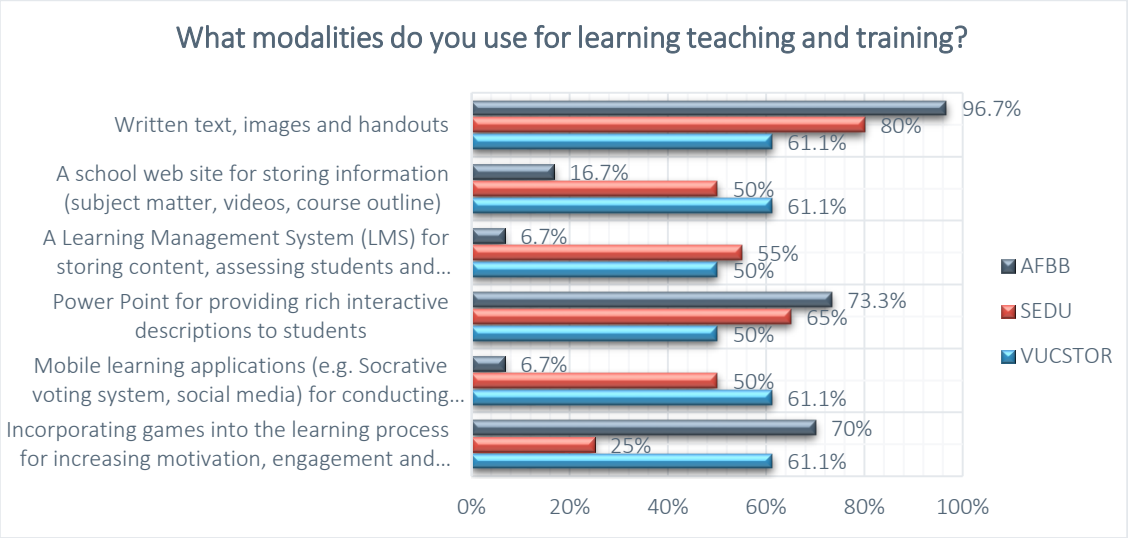

Figure 24 The different modalities used by teachers for teaching, learning and training

The participants were also asked about what mode of learning they would like to use multimodality. The majority of the teachers from SEDU and VUCSTOR (65% and 50% respectively) expressed that they would prefer to use all the modes of learning; face-to-face, blended and distance learning. This result demonstrates that educators value the power of multimodality in teaching and learning independently the mode of learning. In contrast, the majority of the participants from AFBB (51.9%) prefer to use multimodality during only the face-to-face learning. Moreover, several respondents showed their interest in using multimodality for blended learning (both face-to-face and online learning) (27.6% form AFBB, 35% from SEDU and 33.3% from VUCSTOR), while none of teachers is interested in using multimodality for distance learning as a sole mode of teaching and learning.

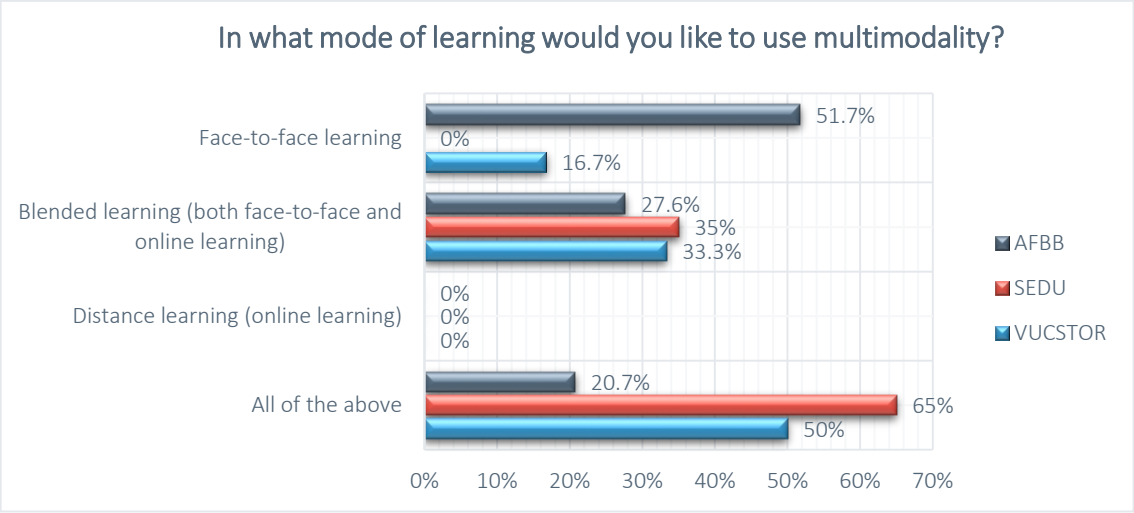

Figure 25 Teachers' preferred modes of teaching and learning for using multimodality

4.2.8 Serious games for teaching and learning multimodality

The aim of the last section of the survey was to provide an understanding concerning whether a serious game (as a multimodal tool) would help the teachers to learn about multimodality for learning and teaching. The participants were asked to choose a definition about what is a serious game. The majority of the participants (43.3% from AFBB, 55% from SEDU and 50% from VUCSTOR) reported that they perceive serious games as a combination of all the given choices. According to these, they define serious games as a digital game that helps students to: i) learn and memorise the content of subject knowledge, ii) understand concepts via applying their knowledge, iii) assess their knowledge through formative feedback, iv) expand their knowledge through investigation and exploration and v) co-develop and share knowledge with the teacher and their peers. This result demonstrates that teachers have a good understanding of what a serious game is, as this definition which was chosen by their majority matches with the definition of the serious games by experts in the literature. However, few teachers gave a definition for serious game by choosing just one of the available options-definitions. For example, 23.3% of the teachers from AFBB, 15% from SEDU and 16.7% from VUCSTOR, perceive a serious game as a digital game that helps students to understand concepts via applying their knowledge. This definition illustrates teachers' perception that serious games promote the application of the knowledge making concepts of learning more interactive and experience-based, however, without being a complete definition. The 13.3% of the teachers from AFBB and the 5.6% from VUCSTOR, highlighted the social dimension of the serious games via the exchanges between teacher-student and among students by stating that a serious game is a digital game that helps students to co-develop and share knowledge with the teacher and their peers.

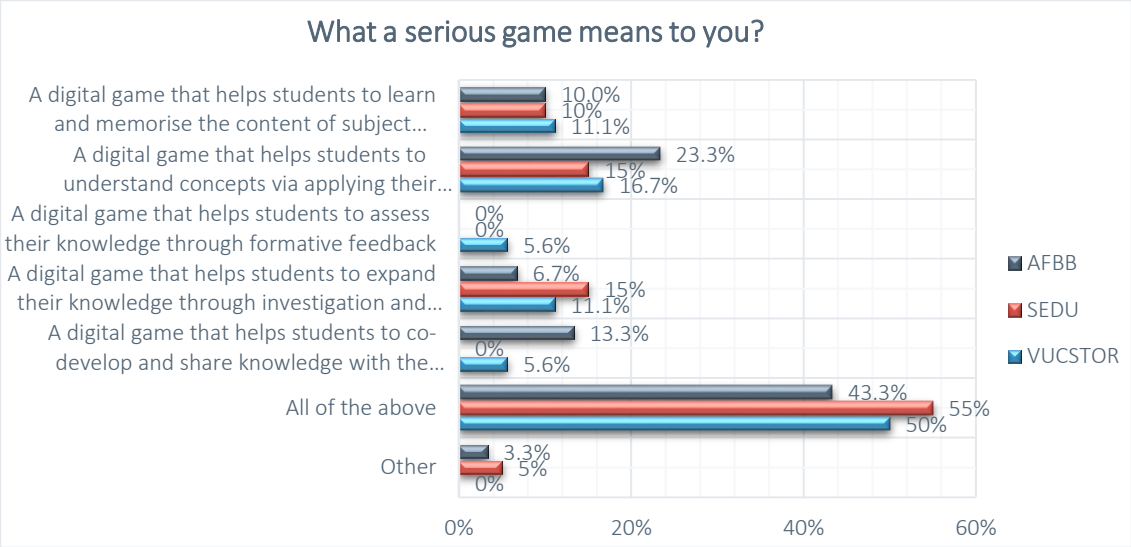

Figure 26 Teachers' definition of serious games

In the next question, the participants were asked to specify what they would like to learn from a serious game. In this question, the respondents had the opportunity to choose more than a single answer. Overall, the majority of the given options seemed to be attractive for the teachers who participated in this survey. Specifically, the most of the teachers from AFBB (80%), the 35% and 44.4% of the teachers from SEDU and VUCSTOR respectively, would like to learn how to use technology for transferring and delivering content. On the other hand, the majority of the teachers from SEDU (80%) and VUCSTOR (77.8%) as well as many teachers from AFBB (60%) would like to learn how to use technology for creating collaborative learning activities. The preference of the teachers to learn how to use multimodal technologies for both creating engaging content and information for transmission but also dialogic and collaborative learning activities might reveal that they would like to use a blend

of practices and make their teaching and learning more interactive and meaningful. A large proportion of teachers demonstrated also their interest in learning how to develop and support online interactions. For example the teachers would like to learn how to use technology:

- To promote better interactions with teachers and students
- For the co-creation and co-design of content
- For improving negotiation, initiation and sharing of ideas

Finally, the teachers as illustrated in the Figure 27 below were also interested in learning how to design assessment and feedback as well how to help their students to become information literate.

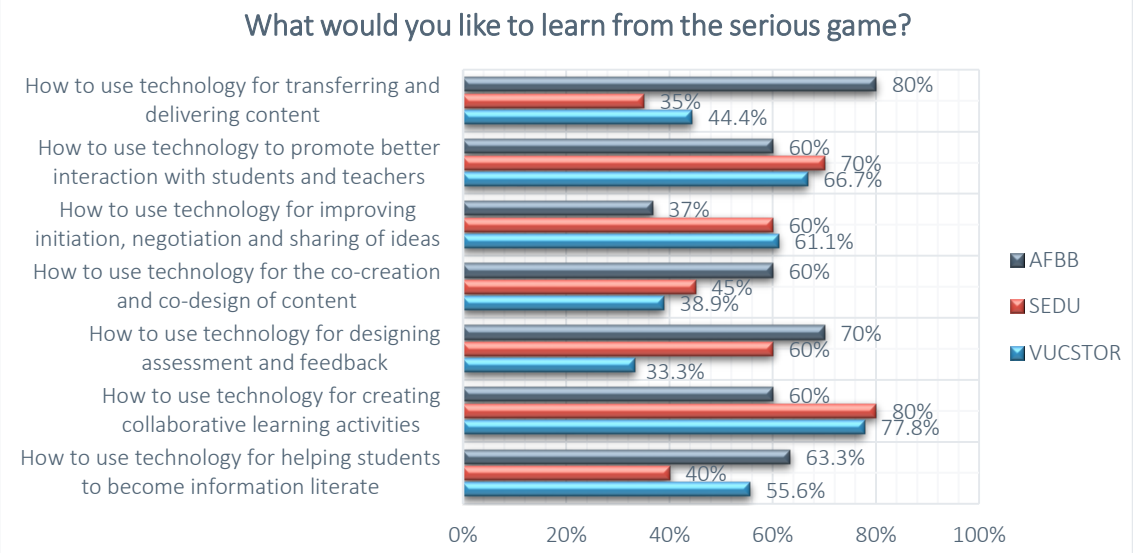

Figure 27 Teachers' preference in learning about multimodality for teaching and learning via a serious game

The participants were also asked to provide their feedback concerning if they would be interested in using a serious game for learning how to utilise multimodality for learning and teaching. As illustrated in the Figure 28 below, the vast majority of the teachers (70% from AFBB, 85% from SEDU and 72.2% from VUCSTOR) responded that they would like to use serious games for learning how to use multimodality. A small proportion of the teachers also expressed that they do not know if serious games will be useful, while only two participants from AFBB showed that are not interested in serious games for learning how to incorporate multimodal practices.

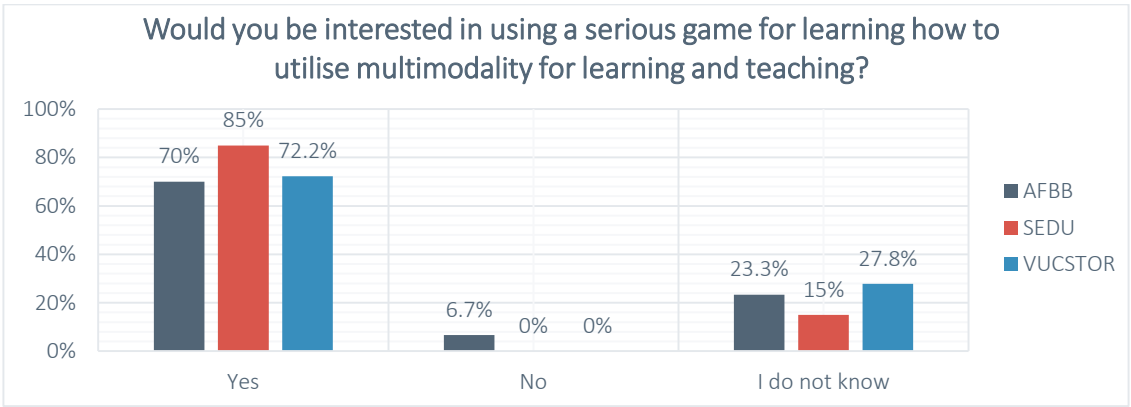

Figure 28 Teachers' interest in using a serious game for learning how to use multimodality

The last question of this survey asked the participants "Why would you use a serious game for learning about multimodality?" As each participant could choose more than a single answer at this question, the most of the participants from all the institutions found that the serious game could have application for a blend of reasons in their teaching and learning process about multimodality. Specifically, the most popular reasons between the others were the use of a serious game for i) the development of teachers' awareness on how multiple learning modalities can be used for learning and teaching (63.3% from AFBB, 45% from SEDU and 55.6% from VUCSTOR), ii) learning how to create collaborative activities during distant, blended and face-to-face learning, iii) learning how to improve the interaction between student and teacher (e.g. feedback provision) , iv) learning how to improve the interaction between student and content. Given that in this survey many of the teachers highlighted that they use multimodality for more individual-based and teacher-directed practices, it seems that they perceive their engagement with a serious game as an excellent opportunity to enrich their knowledge, awareness understanding and possibly practical experience on how to incorporate more interactive, multimodal collaborative learning practices in their classrooms. Finally, few participants perceived that a serious game could teach them how to present content knowledge through written, oral, audio and gestural modalities. This might be due to the fact that they already have sufficient knowledge and use multimodal practices to present content knowledge in their classrooms.

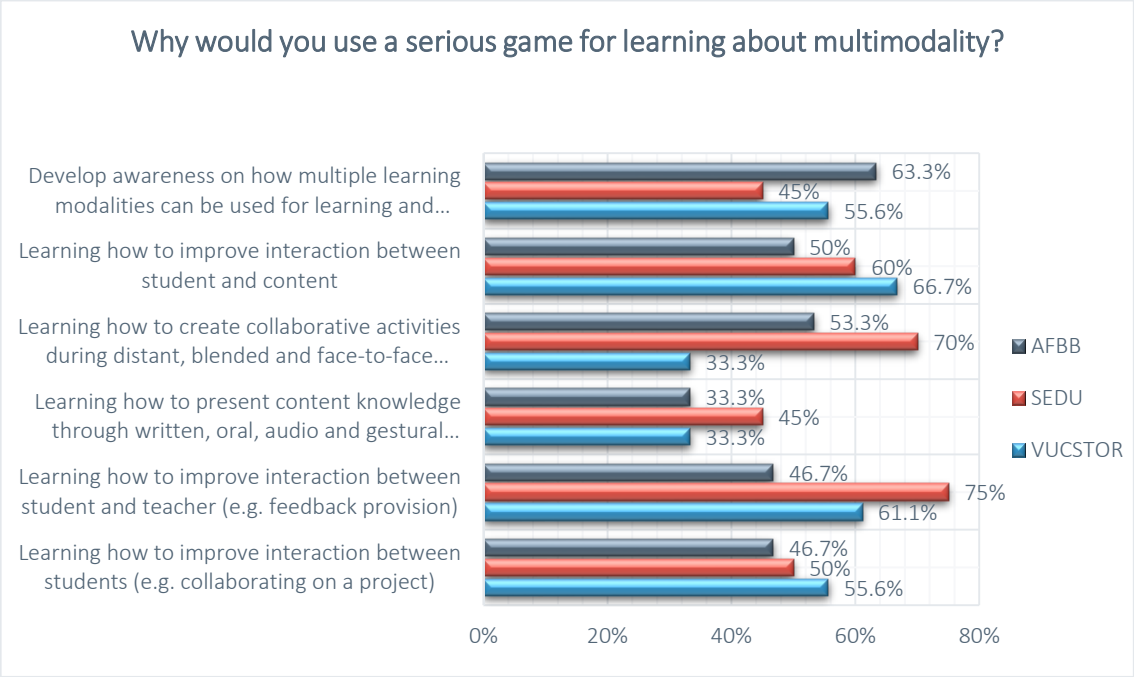

Figure 29 The reasons why the teachers would use a serious game for learning about multimodality

5 DISCUSSION

The deliverable D1.1 ‘‘End-Users analysis’’ provided a comprehensive description of and review on the current evidence-base of multimodality for teaching and learning. The report also provided a survey analysis on end-users’ beliefs, experiences and actions on multimodal approaches deployed in educational institutions in Germany, Finland and Denmark.

We used an evidenced-based approach for retrieving, synthesising and assessing the items in the corpus concomitant to the research questions. The results from the literature review suggest that:

- Multimodality for teaching and learning is based on the process of meaning making through connecting and combining different modes and semiotic resources triggered via social actions and situated choices.
- Multimodality is increasingly perceived and designed to encompass student-centred learning activities by using different semiotic tools and resources such as games, virtual worlds, and other visual representations (e.g. IWBs) for students to create, apply and transfer meaning in their own social context.
- The pedagogical design principles is closely related to multimodal inquiry learning as means to consider the multiple ways we investigate and explore the world around us. Multimodal inquiry learning involves the use multiple resources of communication for engaging actively with questions and problems associated with the subject or discipline.
- The context of multimodal learning and the design of multimodal inquiry activities should take place in both formal and informal learning spaces for broadening up the learning experience.
- Collaborative multimedia learning empowers students to learn from each other, to engage in collective responsibility and collective intelligence for accomplishing a common goal.
  Multimodal information literacy may allow students to find and retrieve information that requires the use of multimodal tools to aid independent and guided information gathering, evaluation, analysis and synthesis for cultivating multimodal information behaviour.
- The role of the teacher switches from one of transferring information to guiding and facilitating the learning process by deploying modes and resources mostly relevant to the student.
- The role of the student is transformed as designer and editor of meaning, researcher, writer and interpreter for getting involved into a meaning-making process aligned to own misconceptions and future leaning.
- Teacher training programs may focus on more visual and immersive mediums for multimodal teaching and learning such as games combined with other technology-supported approaches for supporting communities of practice, peer learning and support.

The outcomes of the end-user analysis survey suggest that:

- Teacher training programs in general and teacher training programs for multimodal learning and teaching in particular should focus on theoretical considerations and practical examples in using technology for pedagogical modalities that support student-centredeness, collaboration, inquiry and formative assessment.
- Multimodal teaching strategies need to be developed encompassing not only oral and written language for information storage and transfer but also tactile, gestural and spatial representations by deploying representational technologies (e.g. mobile and context-aware tools) for encouraging the development of information literacy skills, inquiry competencies and knowledge application in real-world contexts.
- Face-to-face in-classroom multimodal activities should go beyond summative tests and quizzes and be combined with activities realised in informal learning spaces (e.g. fieldtrips, museums, home) for transferability and situating learning to realistic problems and scenarios.

- Teachers need to learn how to use multimodal representation tools that go beyond pen and paper for assigning conventional exercises rather the use of web-based co-authoring tools for sharing, re-use and instant feedback is necessary for promoting multimodal interaction, online discussion and negotiation among students and teacher.
- Teacher training programs need to focus on meaningful feedback provision based on students' prior knowledge and personal interests. Multimodal technologies that promote intrinsic meaningful feedback in a visualised way, through discussion and reflection, on what the student is doing for learning, may help on designing learning based on student's needs and preferences.
- Teacher Training programs should focus on multimodal learning and teaching in blended learning contexts where the use of tools and semiotic resources is more ubiquitous and may be combined with the adoption of multimodal inquiry learning, real-world scenarios, game-based learning, collaboration and information literacy.
- Serious games could be used as training tools for helping teachers to create awareness on how multiple learning modalities can be used for interaction, feedback, collaboration, content delivery and working on a project.

Based on the evidence from the literature study and the survey findings user-needs analysis, we propose the following recommendations:

- The multimodal serious game should focus on training teachers to adopt strategies, approaches and pedagogies that are student-centred where the focus is on student learning, self-direction and personal construction of meaning.
- The multimodal serious game should focus on training teachers based on scenarios that focus on specific aspects of learning and teaching:
    - (1) types of multimodal tools that can be used in the classroom from (web2.0, serious games, IWBs multi-touch, location-based);
    - (2) examples of inquiry-based learning and collaborative activities in relation to relevant multimodal resources and tools;
    - (3) activities (e.g. scientific experiments, explorations in the wild) enacted both in-class and outdoors;
    - (4) examples that show what is the teachers' role in designing and delivering content in multimodal learning environments including classroom management;
    - (5) examples on activities that students in groups are implementing in relation to a web-search for information, evaluate the searched information and present it in class using rich communication representation tools;
    - (6) the serious game may incorporate in-game feedback (scores, progress-bars, notifications) for the players to track their progress and level of learning.

6 CONCLUSION

D1.1 provided a description on what constitutes multimodality for teaching and learning in terms of how it is experienced by educational institutions, schools and students in Europe. The aim of D1.1 is twofold: (1) to analyse, describe and present evidence on multimodal learning and teaching including tools, processes and pedagogical strategies deployed by key stakeholders for enabling multiple models of learning and teaching and (2) to carry out a survey with the STEAM's end-users for eliciting their understanding on multimodality and how it is approached by them. The survey paves the way for perpetuating aspects of multimodal teaching and learning deployed by the 3 end-users of the project: SEDU, VUCSTOR and AFBB.

A set of recommendations are provided on developing the multimodality serious game and on multimodal training, teaching and learning stemming out from the literature study and survey.

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