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The Impact of Multimodal Communication on Learners' Engagement and Comprehension in Online Learning Environments among Science Students at the Secondary Level in Islamabad

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Abstract

This study looks at how multimodal communication affects secondary-level science students' engagement and comprehension in online learning environments. In online education, multimodal communication—which combines multiple information delivery modalities, including visual, aural, and interactive elements—has grown in popularity, especially in science courses that frequently need for intricate explanations and conceptual comprehension. This study investigates the effects of these multimodal approaches on students' motivation, engagement, and understanding of scientific ideas. Surveys and comprehension tests were used to collect data from a sample of scientific students in secondary school who participated in multimedia-rich online learning modules. According to the findings, multimodal communication greatly raises student interest and comprehension of scientific material. Results show that, in contrast to conventional text-based approaches, visual aids, interactive simulations, and additional audio explanations increase comprehension and retention rates. These findings highlight the potential of multimodal communication as an effective instrument for maximizing secondary online science teaching, with useful ramifications for teachers, instructional designers, and educational policymakers looking to improve online learning environments.

Keywords: Key Points Multimodality, Multimodal Communication, Learning Environment, Science Student secondary Level.

Introduction

Because of the surge in other off-campus learning, traditional text-learning is turning into more multimedia conferencing which is technology enshrined E-learning. In these areas, multimedia entails: Videos and audio presentation; Recorded lectures; Audio visual diagrams; simulations; Audio based quizzes and other graphics. It can therefore be presented in the content knowledge in ways that are compatible with the learning mode which corresponds with the modal learning preference of the students (Birch & Sankey, 2008; Moreno & Mayer, 2007). On the same note and of equal importance and, in fact, have grown more critical when it comes to designing specific learning environment types are non-traditional learners. This has produced a stark uncertainty about the specific ways in which learning resources have been delivered to students and how they should be delivered in the present dispensation (Bradwell 2009).

These developments have resulted in posing basic educational questions on what ought to be taught and how on earth this is to be done (Jochems, van Merrienboer and Koper 2004). For many universities this has inevitably required new ways of structures and delivering learning resources servicing the idea-lab to become an issue for discussion across the university (Kellner, 2004). Bradwell states: Teachers and lecturers are faced with a vastly wider range of information processing approaches, cultural contexts and learning profiles. Thus, today the process of teaching in higher learning institution is defined as encompassing far more than just presenting the material, or, as delivering knowledge. Because of increased offering of other off-campus learning, traditional text-learning is being transformed to more multimedia conferencing that is technology enshrined E-learning. In these areas multimedia use involves for instance, video and audio, recorded lectures, audio visual diagrams, simulation, quiz form based on audio and other graphics. Multimedia can This is made more evident by learning styles of these students. These may in fact not be a audience that in fact can be say belonged to the traditional higher ed student category (traditional learner); especially those who – who have already post-secondary learning – can comfortably situated in a read/write mode of learning style (Sarasin 1999). According to Barrington (2004), this is becoming worse because more higher learning institutions (especially in the west) are seen to favor some epistemologies.

Multimodal learning in classroom

In the past decades, the integration of hypermedia along with multimedia have been integrated successfully in many e-learning environments for the purpose of enhancing these environments, and the other types of learning that other students (Birch & Gardiner, 2005; Sankey & St Hill, 2009; Sprague & Dahl 2010). As is the Neuroscience finding, erm Learning points out that 'doubling and other significant increases in learning can be achieved through the purposeful integration of visual and verbal learning and instruction' Fadel (2008). In other words, learners may be more comfortable, and perform better in areas where they choose to learn in a preferred style (Cronin, 2009; Omrod, 2008). Pashler et al, describe this as the 'meshing hypothesis' with the assumption that the meshing accounts for the integration of the inter and intra='') It has also been seen that presenting material in a variety of modes may also encourage students to develop a more versatile approach to their learning (Hazari, 2004); as recent findings in the field of cognitive science suggest:

Objectives

1. To examine the influence of multimodal communication on learners' engagement in online science education.
2. To evaluate the effectiveness of multimodal communication in enhancing comprehension among secondary-level science students.
3. To identify specific multimodal strategies that are most impactful in online learning environments.

Research Questions

1. How does multimodal communication impact learners' engagement in online science education?
2. What is the effect of multimodal communication on the comprehension of scientific concepts among secondary students?
3. Which types of multimodal communication strategies are most effective in online science learning environments?

Null Hypothesis

4. Ho1: Multimodal communication in online learning environments does not significantly impact learners' engagement and comprehension among secondary-level science students.
5. Ho2: Multimodal communication significantly does not enhance learners' engagement in online science education.
6. Ho3: Multimodal communication does not improve the comprehension of scientific concepts among secondary-level science students.

Statement of the Problem

The modern advancement of internet-based learning has brought profound changes in education and offered new chance for learners to gain knowledge. However, when students are separated from their teachers, they rarely get to concentrate, and they do not fully understand what is being taught especially in secondary level science where demonstration and explanation call for physical touch. Although the use of visuals in the form of videos, animations, interactive simulations, and live discussions during the teaching learning process could have a positive effect on the achievement of the learning objectives, there is limited research evaluates on the effectiveness and the level of students' engagement in the online learning contexts using multimodal communication.

This study seeks to address the following questions:

1. In what way does multimodal communication affect learners' engagement in online science learning?
2. How does the use of multimodal communication influence the understanding of ideas and concepts in subjects like science, by secondary level students?
3. Regarding the second research question, the following question is formulated: What does the use of multimodal resources entail for students in online learning contexts?

Significance of the Study

This study is significant for several reasons:

1. **For Educators**: From this, one derives ideas on how the use of multiple modes to deliver content would defensively enhance the engagement levels as well as understandability of sciences, making sure that the dissemination of such knowledge is impactful even in online delivery modes.
2. **For Curriculum Designers**: Implications may help in designing innovative SC activities and course content that is accessible to learners at the secondary level of education.
3. **For Policymakers**: The study focuses on the elements of current teaching aided by technology and underlines significance of funding schools enabling them to utilize multimodal approach.
4. **For Students**: The study advances knowledge in teaching-learning processes by establishing the best practices in the multimodal communication process which in turn optimizes students' grasp of scientific concepts.

Literature Review

Multimodal Communication in Education

Multimodal communication encompasses use of text, graphics, audio and the chance to interact because it addresses learning profile diversity. Several authors indicate that such integration can lead to increased levels of engagement as well as better mastery of the content (Mayer, 2005). According to cognitive theory of multimedia learning, Calgary, that incorporate multiple modes of information enhance the cognitive processing modes that learners (Mayer & Moreno, 2003).

Online Learning Challenges

The shift to online learning has been associated with some of the following issues; low students' participation and challenges with regards to the understanding of concepts (Means et al., 2014). In science education, these challenges are quite eminent because many principles that are taught are abstract in nature (Ashraf, Muztagh, & Salami, 2014).

Multimodal Strategies in Science Education

1. Visual Aids: Sometimes, texts such as diagrams, animations and videos make understanding easier (Hegarty 2011).
2. Interactive Tools: Math captivating simulations and virtual labs promote practical learning techniques (de Jong et al., 2013).
3. Collaborative Platforms: Some techniques such as creating a discussion forum and conducting peer review boosts interaction (Hrastinski, 2009).

Influence on Interaction and Understanding

Research, as depicted in Guo, Kim & Rubin (2014) has shown that, the use of multimodality leads to high students' motivation and participation. Further, it has been argued that instruction that facilitates students' use of multiple modalities foster in their rate of retention and comprehensiveness of the content as presented by Najjar (1998).

Methodology

The study employed a **quasi-experimental design** to examine the impact of multimodal communication on learners' engagement and comprehension. A mixed-method approach was used, combining quantitative measures (e.g., pre-tests, post-tests, engagement scales) and qualitative data (e.g., focus group discussions and open-ended surveys).

Procedure:

1. Two groups of secondary-level science students were selected:
   - **Experimental group:** Exposed to multimodal learning materials (videos, audio lectures, animations, infographics, and interactive quizzes).
   - **Control group:** Exposed to traditional text-based online learning materials.
2. The intervention lasted for six weeks, covering science topics from the students' curriculum.
3. Data collection occurred before and after the intervention to evaluate changes in engagement and comprehension.

Prior to experiment
1.Inclusion of interest and call to students to participate 2.All the students who want to are given a VARK learning styles inventory and make completion of it. 3.The way learning styles is being spread can be used in selecting the participants. 4.Distribution of experimental group, date and time for experiment
During experiment
5. The pre-test of concepts to be learnt in this study was conducted twice; before subjecting the respondents to each of the learning scenarios. 6. Interactions related to completion of other learning scenarios (x2) 7. After exposure to each learning scenario, the post-tests (x2) 8. Upon the end of the experiment, students are required to fill online survey.

The target number of samples was 60 but among them 10 participants were assigned to each of the experimental groups. Each participant was trained two learning concepts but this learning concept was taught in two learning conditions to each participant. The target was to ensure there is at least 2 participants from each of the five multiple intelligences, namely the visual, auditory, read/write, kinaesthetic as well as the multimodal. out of the participants agreeing to feature in the experiment, only four out of them had dominance of the 'aural' learning style. The "multimodal" was the most often chosen learning mode by those who were ready to be involved in the experiment. Where some of the researchers failed to garner enough participants of one of the most prevalent learning styles, a multimodal learner was recruited to make up for any of the identified groups.

Tools

1. **Learning Management System (LMS):** An online platform delivering the content.
2. **Engagement Scale:** Adapted from a validated engagement inventory (e.g., Fredricks

et al., 2004).
3. **Pre- and Post-Tests:** Developed by subject experts to assess comprehension of the science topics.

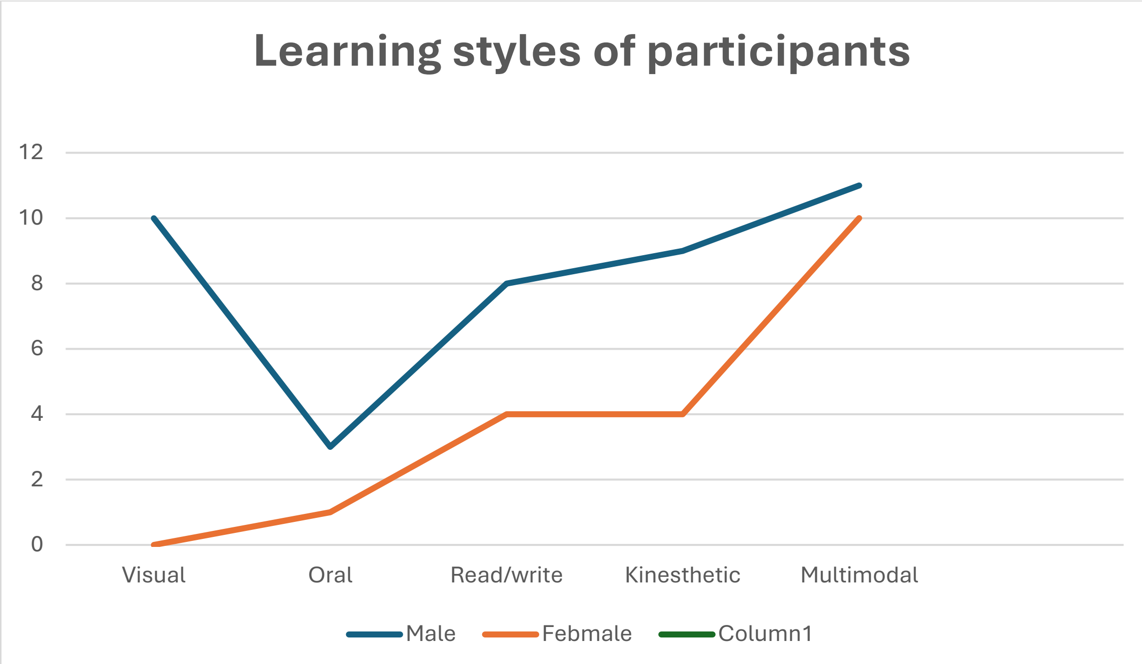
Sample
- **Population:** Secondary-level students enrolled in science courses.
- **Sample Size:**
  - Experimental group: 50 students
  - Control group: 50 students
- **Sampling Method:** Purposive sampling was used to select students with similar academic backgrounds and familiarity with online learning platforms.

Analysis
1. **Quantitative Analysis:**
   - Paired t-tests compared pre- and post-test scores within and between groups.
   - Descriptive statistics analyzed engagement scale responses.
   - Interaction data from the LMS (e.g., time spent, completion rates) was analyzed using ANOVA.
2. **Qualitative Analysis:**
   - Thematic analysis of focus group and survey data identified patterns in students' perceptions of multimodal materials.

Learning styles of participants

Predominant teaching learning process	Female	Male	Total
Visual study	9.7 (24.4%)	0 (0%)	10 (16.7%)
Oral question	2.6 (7.3%)	2 (5.3%)	4 (6.7%)
Read/write paper	7.8 (19.5%)	6 (21.1%)	11 (20.0%)
Kinaesthetic study	8 (22.0%)	8 (21.1%)	12 (21.7%)
Multimodal style	10.7 (26.8%)	12 (52.6%)	23 (35.0%)
TOTAL	39 (68.4%)	19 (31.6%)	60 (100.0%)

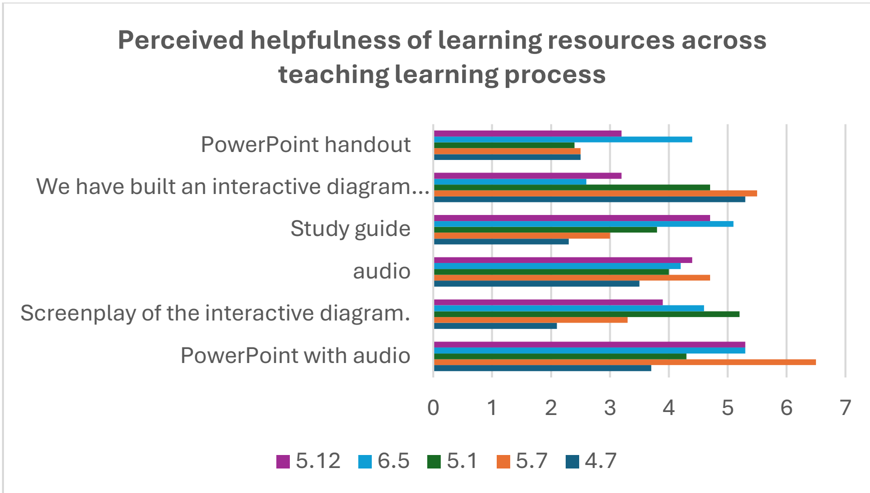
Most of the participants in the sample (70%) had a grade point average of 4.0 or above (out of6.0) with only 7% of students with a grade point average of less than 5.0, indicating that very few lower-achieving students elected to undertake the experiment. There were no significant differences found across the six experimental groups with respect to gender, age or grade point average.



Perceived helpful style of learning resources across teaching learning process in class room

Learning resource	Visual	oral	Read/write	Kinesthetic	Multimodal	Ave
PowerPoint with audio	4.7	5.7	5.3	6.5	5.7	4.68
Screenplay of the interactive diagram.	3.7	6.5	4.3	5.3	5.3	3.42
audio	2.1	3.3	5.2	4.6	3.9	4.22
Study guide	3.5	4.7	4.0	4.2	4.4	4.16
We have built an interactive diagram with a script only.	2.3	3.0	3.8	5.1	4.7	2.98
PowerPoint handout	5.3	5.5	4.7	2.6	3.2	5.66
Textbook reading	2.5	2.5	2.4	4.4	3.2	2.20

Participants were also asked several questions involving the different learning resources in an interview, Perceived helpful style of learning resources across teaching learning process in classroom. The responses that were obtained in many cases reflected the participant's preferred mode of learning. Some of the participants used the learning resources to support their learning and suggested which learning resources supported their learning best, were easiest to use, more interactive or more enjoyable.



Results

1. **Comprehension:**

○ The experimental group showed a statistically significant improvement in post-test scores compared to the control group ($p < 0.05$).

○ Students in the experimental group had a 20% higher average comprehension score.

2. **Engagement:**

○ Engagement scores were significantly higher in the experimental group, with students reporting greater interest and motivation.

○ LMS data revealed higher interaction times for the experimental group (average: 45 minutes/session) compared to the control group (average: 25 minutes/session).

3. **Qualitative Findings:**

○ Students in the experimental group found multimodal content more engaging and easier to understand.

○ Common themes included the benefit of visual aids in understanding complex science concepts and the value of interactive activities in sustaining attention.

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