The Relationship between Notetaking, Revision, and Learning in Tertiary Education: A Review of Literature, 1970 - 2023.

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Abstract.

The aim of this paper is to highlight the complexity and the central importance to academic achievement of taking and reviewing notes at third level. It is based on a review of international literature on the notetaking process between 1970 and 2023. The paper describes notetaking and reviewing as the method of encoding and externally storing new material, for the purpose of advancement in learning and attainment in assessment. It outlines research on the benefits of typed versus handwritten methods of notetaking. The overriding outcome demonstrates that taking notes, either by longhand or typing, produces superior results than not taking and reviewing notes. The remainder of the review focuses on the status of notetaking instruction in third level colleges and universities. It is observed that despite the centrality of notetaking to educational success, and the positive impact of instruction on taking notes, skills training and modelling are generally not taught or embedded in the curricula in tertiary education. Furthermore, the paper describes teaching strategies alongside linear and non-linear notetaking methods that have been shown to encourage students to take and revise notes which has, in turn, led to the enhancement of learning. The conclusion reviews the main points of the article and its limitations. A further review of literature on the examination of cognitive and metacognitive functions on notetaking would contribute to the understanding of how notetaking and revision operate to increase students' capacity for recall, comprehension, and knowledge.

Keywords: Encoding; External storage; Instruction; Linear and non-linear notetaking; Longhand and typing.

1. Introduction.

For over 50 years notetaking has been regarded as an essential skill in third level education. It

requires multimodal processing, predominantly involving the sub-skills of either writing or typing and is underpinned by a limited storage capacity and working memory system (Peverly et al., 2007). According to Siegel (2023b) the critical role played by notetaking and revision in education is not comparably matched by research investigating its contribution to the advancement of learning or by its instruction at third level. The translation of thoughts and ideas into written text relies on higher and lower order skills which place heavy demands on the writer's cognitive and metacognitive resources. Transcription and spelling are commonly regarded as lower order capabilities, while analytical and evaluative functions are regarded as higher order skills (Connelly et al., 2006; Stewart, 1989; Wong,1999). Conversely, it has been contended that handwriting is a cognitively challenging task that requires the sequential integration of orthographic information with motor skills for the generation of text (Berninger et al.,1994). The automation of writing through the use of a word processor enables the reduction of cognitive load while also producing quality script. Potential advantages afforded by typing include speed, ease of text modification and the use of software such as spelling and grammar checks (Christensen, 2004). A meta-analysis of the effect of media usage on academic achievement, however, by May and Elder (2018) found that the distractions that resulted from multitasking with the use of technology had a negative impact on attention, working memory, and notetaking.

Writing enhances understanding and knowledge of the topic about which the student is writing (Drabick et al., 2007; Klein & Yu, 2013), thereby underpinning its significance to notetaking. While notetaking is intellectually less demanding than the production of an original composition, it is more challenging than studying and reading (Piolat et al., 2005). The substitution of longhand notetaking with typing on a computer, according to Bui et al. (2013) reduces cognitive effort and provides an equalising strategy for students with lower functioning working memory. There is extensive agreement in the literature that cognitive processes such as memory, comprehension, cognition, and metacognition are stimulated and supported by notetaking. Disparities exist between theories, though, on how the conventional form of handwritten and more recently typing, as the two most frequently used approaches to notetaking, impact on discovery, and recall (Brown, 1988; Lin & Bigenho, 2011). There are further variations in accounts about the benefit of linear and non-linear approaches to notetaking; notes written in sentences, or with the use of mind maps and matrices, and on the impact of revision on learning (Kiewra et al, 1991; Lu et al., 2020).

This paper is concerned with the benefits to learning of taking notes by longhand or with a word processor, the advantages to students of reviewing their own or borrowed notes, and the

comparison of notetaking strategies for the advancement of education. In its examination of the literature between 1970 and 2023 the aim of the review is to explore the relationships between notetaking and learning in higher education.

This is a narrative review that was conducted over a 55-year period for two main reasons; primarily it demonstrates the enduring nature of the significance of notetaking at third level. The review provides evidence of the extent to which research, undertaken in the late 20th Century continues to be relevant to tertiary education in the 21st Century. Furthermore, the 55-year trajectory shows that the development of understanding of notetaking has occurred in a constructive and cumulative manner which currently incorporates non-linear and digital notetaking, but not to the exclusion of previous notetaking methods.

The main databases accessed for the review were PsycArticles via EBSCO, PsycINFO, APA PsycNet, ELSEVIER, ScienceDirect Freedom Collection, ERIC, JSTOR, ProQuest, and Google Scholar. Search terms used include, but were not limited to the following: notetaking at 3rd level; digital notetaking at third level; enhancing processing and memory through notetaking; strategies for taking notes; reviewing notes for increasing understanding and memory; comparing handwritten with typed notetaking; linear and non-linear notetaking; comprehensive notetaking; lecturers' notes; detailed notetaking; combined influence of notetaking and reviewing; notetaking in STEM and non-STEM subjects; advantages of notetaking and/or reviewing notes; impact of notetaking on advancement of learning; efficient notetaking.

Research and meta-analysis studies included in this review are from peer reviewed journals written in English and predominantly related to tertiary education. The inclusion of studies on writing relating to primary and post-primary students occurs when it provides context to the overall notetaking process. Studies involving research with students for whom English is an additional language and students with dyslexia are included when they offer comparable information on notetaking. Research on the influence of test mode and on the cognitive and metacognitive aspects of notetaking are excluded on the basis that these topics require a separate and comprehensive inquiry.

Section two outlines how encoding and external storage, as the essential factors involved in notetaking, contribute to the development of students' learning. Section three examines the benefits of taking handwritten and typed notes and the advancement in learning that can be gained through the revision of notes. Section four investigates diverse strategies of notetaking including concept maps and matrices. It compares the efficiency, effectiveness, enjoyment, and

performance outcomes of new strategies to conventional methods. Section five discusses the implications of research findings for teaching notetaking strategies in third level colleges in Ireland. The conclusion synthesises the main findings with suggestions for effective notetaking strategies that have been shown to positively influence learning outcomes for third level students. It also outlines some of the limitations of this paper.

2.   How Notetaking and Revision Work.

The cognitive effort involved in notetaking, operating out of working memory, pertains to the student's ability to comprehend, select, and record important concepts within a limited time frame. Subsequently, it involves the aptitude to engage with, study, synthesise, and recall the relevant information in a variety of contexts (Bui & Myerson, 2014; Gernsbacher, 1991; Gur et al., 2013; Wu, 2020). The functions of encoding (notetaking without review), external storage (reviewing own/borrowed /lecturer notes) and encoding along with external storage have been established by Di Vesta and Gray (1972) as the significant properties of notetaking. They provide students at the time of taking notes with processing and, later, with revising opportunities that reinforce learning. Notetaking on its own, devoid of revision is superior to not taking notes as it has been shown to lead to higher educational attainment (Kiewra, 1985a). An investigation of the encoding effect of notetaking by Einstein et al. (1985) measured the quantity and quality of concept retention for 48 college students who attended a lecture, half of whom took notes but were not permitted to review them while the other half just listened. Results demonstrate that students in the notetaking group remembered more significant facts that the listening-only group, providing evidence of the organisational and processing function of encoding. However, a meta-analysis of studies on the encoding function by Kiewra (1989) and later by Kobayashi (2005) found that the performance advantage afforded to students by notetaking varied; in the case of recognition tests, it did not significantly deviate from recall by students who did not take notes. Kobayashi explained the outcome in terms of Thomson and Tulving's (1970) coding specificity principle (relationship between conditions at time of encoding and retrieval) i.e., cues provided in recognition tests supersede the need for notetaking and encoding. Contrarily, recall assessments make demands on mental retrieval cues which are supported by taking notes.

The interpretive and summarising properties of notetaking and revision underpin higher order processing, the generation of knowledge, and superior recall for students (Rickards & Friedman,1978; Shrager & Mayer, 1989). In contrast non-notetakers have been found to

perform well at short-term recall but not at in-depth comprehension (Peper & Mayer, 1986). Similarly, research has shown that the transcription of notes verbatim has assisted short-term memory but has not led to the development of understanding (Bretzing & Kulhavy1979). However, a meta-analysis of 57 studies on the encoding effect of notetaking and not taking notes by Kobayashi's (2005) found stronger positive outcomes of encoding in the retention and recall of information than in the reinforcement of understanding of what was written. This result may be accounted for by the typically fragmented nature of notes that students take, due to the complex attentional demands of a lecture (Bui & McDaniel, 2015).

The robust effect of external storage on recall, comprehension, and academic performance is shown by studies where students were given the opportunity to revise notes, including notes taken by others and lecturers' notes (Fisher & Harris, 1973; Maqsud, 1980). In a study comparing the effectiveness of encoding with external storage, Knight and McKelvie (1986) assessed the quiz results of 144 psychology undergraduates who had viewed a video of a lecture on a new but discipline related topic. Participants who reviewed detailed notes received from their lecturer performed better than students who reviewed their own less organised notes. They, in turn, achieved higher results than those who did not review their own notes. Additionally, research showing the advantage of external storage over encoding in the generation of knowledge is demonstrated in a study by Kiewra et al., (1988a, as cited in Kiewra, 1989); students who did not attend a lecture but, instead, borrowed, and reviewed notes performed better in a test requiring conceptual processing, than note takers who did not review their notes.

The research shows that notetaking plus reviewing provide better recall to either encoding or external storage alone. Combined encoding and storage, and external storage alone also provide better results in the comprehension and integration of information, to encoding on its own. This can be explained in terms of time spent processing and revising. Importantly, the evidence suggests that the combined influence of taking and reviewing notes are significantly greater than not doing so (Kiewra et al., 1991; Kobayashi, 2006).

Studies that have been undertaken on the educational advantage accrued to students by taking handwritten or typed notes is another important research area worthy of review.

3.   The Benefit of Taking and Revising Longhand and Typed Notes.

The advances afforded to learning by technology and the use of word processors at third level has broadened students' options for notetaking strategies (Skolnik & Puzo, 2008; Williams & Beam 2019). The digitisation of literacy, with its technological software, provides for the seamless integration of thought, language, and writing (Kruse et al., 2019), suggesting the potential for heightened efficiency and proficiency in notetaking. Supporting this belief, research carried out by Bui et al. (2013) found that when testing occurred immediately after notetaking, with no opportunity to review notes, those who had used a computer to transcribe notes achieved higher scores on factual recall than those who had handwritten notes. A further experiment by [ibid]showed that when the assessment did not immediately follow the lecture, participants who took structured computer notes outperformed those who typed verbatim notes. A third experiment [ibid]found that when assessments were delayed and participants were given an opportunity to review their notes, those who typed the lecture verbatim demonstrated superior recall than those who had typed structured and synopsised notes.

Proponents of handwritten notes, however, argue that in processing and summarising information, for the purpose of longhand notetaking and in the absence of the opportunity to review notes, new learning is generated by creating connections with preexisting encoded material (Einstein et al, 1985; Peper & Mayer, 1978). Mueller and Oppenheimer's study (2014) compared notetaking strategies and learning outcomes using longhand and keyboards. They discovered that after one week, during which time students were allowed to review their notes, those who had taken handwritten notes scored higher on factual and conceptual assessments than their counterparts who had typed their notes. Concurring with these results a study conducted by Crumb et al. (2022) found that participants who took notes by hand and were given 10 minutes to study them, scored higher in a quiz that was administered two days later than the students who had typed and reviewed notes. Participants who used computers were asked, and reported overwhelmingly that they did not experience distractions e.g., the use of social media, thereby eliminating distractibility as a reason for the results. The authors interpreted the findings as evidence that notes taken by longhand require additional processing for their summation. Handwriting, therefore, positively influences encoding and revision resulting in greater conceptual recall, while typing facilitates verbatim notetaking. However, a replication and extension of Mueller and Oppenheimer's study (2014), which included ewriting

techniques and non-note takers, by Morehead et al. (2019a), failed to find consistent variances in the performance of longhand and digital note takers. The differences that did exist between the groups, including non-note takers, were found to be minimal when students had an opportunity to revise notes. Results show that while longhand note takers recorded fewer transcribed notes and had processed more concepts in comparison to their typing counterparts, the method of notetaking did not impact on test achievement (Colliot et al. 2022).

The evidence suggests that the variance in student performance resulting from handwritten or digital notetaking is due to the inherent differences in students' choice of notetaking methods. Studies where interference and distractions were eliminated found no significant differences in academic performance resulting from typing and writing notes by hand. Differences found in previous studies may be explained by the confounding effect of interruptions while using a computer (Artz et al. 2020; Voyer et al., 2022). The availability of hybrid notetaking options, according to Siegel (2023a), such as digital pens and touch screens will enable students to choose a strategy or a combination of notetaking methods that match their preferred writing style.

4.   Approaches to Notetaking and Reviewing.

Coherent notes that are focused on important conceptual and relational themes enhance academic performance to a greater extent than notes with factual and unrelated content (Kiewra & Fletcher, 1984). Lecturers' notes have been found to be more detailed and therefore of greater benefit to students than their own notes (Kiewra, 1985a; 1985c). Access to comprehensive external notes, however, is not always an option. It also takes responsibility for learning away from the adult learner and it is important for students to be able to take effective notes or have access to a combination of both. The provision of outlines and matrices as prompts for students' notetaking prior to a lecture has the potential to maximise student engagement. Furthermore, they serve as focused and organised revision tools for assessment (Armbruster, 2000). They have been found to improve academic performance to a greater extent than conventional notetaking (Bui & McDaniel, 2015; Hartley, 1976; Kiewra et al., 1991). Kiewra et al.'s research (1988b) compared the performance of students who didn't take notes but who reviewed notes in three different conditions: 1) complete set of lecturer's notes 2) outline notes 3) matrix notes. The study found that the performance of all participants in the experimental groups was superior to that of the participants in the control group who did not get any notes to review. Students in

the outline and matrix groups demonstrated better recall than those in the group with complete lecturer's notes. Participants in the matrix group showed the highest level of ability to transfer and synthesise information.

Adults' listening rate has been estimated to operate at approximately 210 words per minute (Omoigui et al.,1999). This compares to the speed with which they can write at about 22 words per minute (Brown, 1999) or type at approximately 33 corrected words per minute (Karat et al.,1999). The differential between listening and writing or typing underliesthe emphasis in research on the importance of structure in taking comprehensive notes. The use of graphic organisers such as matrices and concept maps, which are most commonly used, enable students to record valuable information from lectures or texts in a spatially relational manner. Disparate to sentences and paragraphs, these methods streamline content and facilitate time efficient revision (Larkin & Simon, 1987).

4.1 Linear and non-linear notetaking; sentences in lines versus concept maps, outlines, and matrices.

Linear notetaking, according to Jairam and Kiewra (2010), does not visually represent relationships between concepts. Unlike the most commonly used graphic organisers i.e., matrices and concept maps (Buzan, 2018), sentences and paragraphs do not efficiently record information. Okafor (2016) compared the academic achievement in Geography for students in the control group who took linear notes, with experimental group one recording outline notes, and group two taking notes with concept maps. The results showed that both experimental groups performed better than the control group, with the students who used concepts maps out performing all the others. Okafor interpreted the finding to indicate that concept mapping by students enables active organisation and participation in the learning process. This leads to the ability to link newly acquired information with that already stored in memory. Supporting this research, a qualitative study conducted by Erdem (2017), which involved semi-structured interviews with 31 undergraduates at a university in Turkey, found that students predominantly reported the advantages of using mind-maps for study. The students explained that concept maps deepened their understanding and strengthened their recall for information presented at lectures. The negative aspect in this research, was found to be with drawing difficulties and memorising the meaning of the symbols used in the map. Erdem points out that the increasing sophistication afforded by technology will make it easier for students to design and create mind-maps.

A matrix has the capacity to organise information according to both the topic being studied and the broader category to which it belongs. This reduces cognitive load for the student by creating learning links and strengthening recall and comprehension (Kauffman & Kiewra, 2010). Two studies by Kauffman et al. (2011) explored online linear approaches and online non-linear notetaking methods such as outlining and matrix devices, with 30 and 119 participants respectively. They found that the matrix tool collected superior information, which was subsequently reflected in higher learning outcomes. Jairam et al. (2012) cautioned, however, that not all matrices contribute equally to learning. Their research with 53 participants discovered that when matrices are used holistically and categorically, they result in the formation of stronger links between topics and the highest performance on factual recall and synthesis of information.

Evidence from the literature elucidates the advantages to students of using non-linear formats such as metrices and mind-maps (longhand and typed); high ratings for efficiency, enjoyment, and ease of use; comprehensive notetaking; superior scores in factual recall, and the development of conceptual links (Swestyani et al., 2018). The established relationship between the notetaking process and learning success alongside the multifaceted skills required for efficiency in taking notes suggests the necessity for its instruction in tertiary education (Siegel, 2020; Watnuf, 1959).

5.   Teaching Notetaking Skills at Third-level Colleges.

From the middle of the 20th century to the present-day notetaking and reviewing have and continue to be universally employed by students and empirically linked to successful learning outcomes (Dunkel & Davy,1989; Peverly et al., 2003). While the complex and critical nature of taking and revising notes is recognised, the third level curricula does not typically include instruction on notetaking. The focus of lectures tends to be on content rather than teaching or modelling learning strategies (Applebee, 1984; Rachal et al., 2007). An empirical study of 20th century notetaking patterns at the University of Georgia, by Palmatier and Bennett (1974), found that the majority of the 223 participants surveyed valued and took notes. The participants reported that instruction on notetaking skills was not part of the programme of studies at the University. Research on students' opinions on notetaking, conducted almost 50 years later by Salme and Thomson (2020) with 160 students attending a US university provides similar results. The participants predominantly reported a high regard for notetaking. This was evidenced by

enhanced learning and assessment achievement as a result of taking notes strategically. The study further found that students who did not value notetaking did not take well organised notes and gained a significantly lower grade point increase in their assessments compared to their peers who took strategic notes. The authors' deduction from the results of notetaking as an important skill, led them to advocate for notetaking instruction at the earliest stage of students' college experience. While there is a dearth of research on notetaking in tertiary education in Ireland a tangential study conducted at the University of Limerick (UL), by Cleary et al. (2009), highlights the fragmented approach to writing instruction at third level, which led the authors to recommend academic writing instruction for the advancement of students' success. Digital notetaking workshops were initiated at the University of limerick in 2022 and continued to be available to students in 2023 (University of Limerick, 2023).

The development of technology has provided an array of options on how notes are taken. An investigation of 21st century notetaking behaviours conducted by Morehead et al. (2019b) found that there was greater versatility with the use of both longhand and digital notebooks. However, over half of the 577 students surveyed reported an absence of, or inadequate training in notetaking while also indicating that instruction would be well received and beneficial. Training in notetaking that is embedded within the lecture content provides the strongest learning opportunities for students (Chen et al., 2019). Research by Haghverdi et al. (2010) on the effectiveness of notetaking instruction found that participants who had received teaching in this area achieved superior scores to those who had not. This led the authors of the study to indorse tuition in notetaking. Active engagement with the lecture material is a key factor for learning (Strobel &Van Barneveld, 2009). It involves the ability to discriminate between important and irrelevant material and to synthesise information. A meta-synthesis of ten studies was carried out by Reed et al. (2016) to investigate students' academic performance as a result of face-to face notetaking instruction provided over an extended period of time. The tuition was predominantly on split-page (page split vertically to record cues and explanations from the lecturer) and guided notetaking (lecturer provides an outline which the student completes in more detail from the lecture content). The results show a positive correlation between instruction on notetaking and academic performance with a stronger and more constant relationship between direction on guided notetaking and learning outcomes.

Instruction in active listening and hand drawing skills, for recording and organising information efficiently on concepts maps, has been deemed necessary for students to benefit optimally from new non-linear notetaking methods (Armbruster (2000; Tee et al., 2014; Zipp et al., 2009).

Robust evidence demonstrating the superior performance of students who use matrices for notetaking, according to Kiewra (2002), warrants instruction in how to 1) review completed matrix notes from lecturers or, 2) complete partial matrices and 3) create matrices for notetaking. Kiewra further proposes that modelling the use of matrices while delivering a lecture will concretise the strategy for students. The integration of learning outcomes and assessment into the teaching of concept maps further strengthens students' critical thinking skills and generates learning (Noonan, 2013).

Research demonstrates that the coexistence of conventional and new technologically advanced methods provides the most integrated approach for students, providing them with bimodal options (visual and verbal processing) for notetaking and learning. It suggests the necessity for tuition in the use of comprehensive graphic organisers and instruction in longhand notetaking techniques (Colliot et al., 2022; Davies, 2011; Haas, 1999).

6.   Conclusion.

In a review of the international literature on notetaking in third level colleges between 1970 and 2023, this paper highlights the significance to academic success of taking and reviewing notes. Notwithstanding its intricacy, notetaking is widely regarded as under researched, with little scheduled tuition for it in the tertiary curriculum in Ireland. It has been established empirically that the key processes involved in notetaking are encoding and external storage. The contention that time spent processing material while taking notes increases learning outcomes, is supported by the literature. Furthermore, the argument that the revision of notes, either one's own or borrowed, leads to superior achievement in learning is also underpinned by academic research. Both processes combined have been shown to enhance memory. Together, the encoding and storage procedures along with external storage on its own have been found to increase the interconnection of concepts and the understanding of material being studied.

Technological and digital developments have led to the investigation of writing mode; the potential advantage to students of taking notes by longhand or with a keyboard. Scientific evidence suggests that typing enables both verbatim and structured notetaking which subsequently increases the factual recollection of information. Furthermore, the summarising function involved in writing notes by hand has been shown to generate new learning. However, research illustrates that when distractions are eliminated and there is an opportunity for revision, the advantage of one mode of notetaking over another is negated. This suggests that students'

preference for either typing or handwriting, rather than the mode itself, determines assessment performance. Digital advancement has provided students with the choice of notetaking modes. The amalgamation of both is available to students but is contingent on their training in notetaking and in the use of technology.

Notes that contain coherent and related concepts have been demonstrated to provide greater learning opportunities and a stronger advantage in assessments than fragmented notes. There is broad agreement in the literature that non-linear notetaking provides an efficient and effective means of recording important information. Concept maps and matrices, longhand and typed, create a greater capacity than traditional linear methods for organising information conceptually and relationally. They thereby empower higher order processing with reduced cognitive effort. Digital technologies further enable detailed linear and non-linear notetaking and are significantly associated with higher scores for comprehension and factual recall.

While notetaking and reviewing methods have evolved over the past 50 years their relationship to learning outcomes at third level remains the same. Similarly, the curricular focus in third level colleges remains largely unchanged, with the emphasis being on lecture content over learning strategies. Studies, however, show that students acknowledge both the value of taking notes and tuition on notetaking methods. Instruction and modelling in the use of linear and non-linear strategies have been demonstrated to enable students to store important information succinctly and accurately. Research further proposes that notetaking instruction on important skills such as listening discriminatively, synthesising material, and the use of pictographic mapping results in the achievement of higher assessment scores for students.

Limited working memory capacity is an important factor in taking and revising notes. It is not included here as it constitutes a more detailed examination than could be afforded in this review. Research showing that non-linear notetaking and reviewing requires less cognitive effort than linear notetaking, warrants a review of the literature on the relationship between notetaking strategies, successful learning outcomes, and working memory.

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