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Leveraging Domain Practices to Improve Academic Literacy in Undergraduate Computing Students

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ABSTRACT

Undergraduate students often find the process of collating research results and producing structured written text from this difficult. Research suggests that those with a writing strategy and those who leverage visual modelling techniques to structure their research or writing had an advantage over those who did not. There are strong parallels here with the field of software engineering in terms of established processes and the use of visual models. We hypothesise that undergraduate computing students will adopt Mind Maps (a visual modelling technique) as a tool in their writing process. To explore this, we conducted first a survey to better understand students' attitudes towards academic research and also a practical intervention, involving mind-mapping their research proposals prior to writing their literature reviews and full research proposal. Our investigation indicates that mind maps can serve as effective intermediary tools for organizing concepts and structuring academic writing, with parallels observed between their use and formal modeling methods such as UML diagrams. Survey and intervention data demonstrated that students who engaged in mind-mapping prior to drafting research proposals exhibited measurable improvements in literature density and overall proposal quality, though participation was voluntary and potentially biased toward more motivated students. Nevertheless, because improvements were assessed against individual baselines rather than cohort-wide performance, the results substantiate the pedagogical value of mind mapping as a research-support strategy.

Keywords: Domain Practices; Academic Literacy; Research Skills; Undergraduate; Mind Map

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1. Introduction

To undergraduate students, academic research can initially be a daunting process, pupils struggle to process the results of their searches and to structure written text from this research [1–4]. Torrance, Thomas and Robinson suggested that research students who had a distinct writing strategy (e.g., plan then write or write then revise) did not find writing difficult unlike those who adopted a mix of techniques (suggesting no established writing strategy) [5]. They also highlight the use of visualisation techniques to organise information among graduate students.

Mapping techniques can help students organise information [2, 6], promote "deep" learning [2], and possibly support dyslexic students and have been used to plan written text [1, 5, 7].

We propose that providing computing students with a means to map their research will encourage them to search for the relationships between the concepts uncovered and organise their sources of information accordingly. This, in turn, will aid the research process, allowing students to visually identify topics that are under-researched. Also during the writing process the map can aid students in structuring their report, ensuring they include all the research they have undertaken and distribute the word count between sections. While we acknowledge that these techniques may not work for all students due to differences in writing strategy we believe that the similarity to diagrams used to provide abstract visualisations software design may encourage adoption [5].

2. Literature Review and Background

Lea and Street highlighted perceived problems in academic literacy at university level [8]. In their work learning in higher education as is defined as"adapting to new ways of knowing: new ways of understanding, interpreting and organizing knowledge" [8]. Reading and writing within a discipline (academic literacy practices) are therefore a central process by which students learn new topics and expand their knowledge of others [8]. Wingate suggests a broader definition of academic literacy as "the ability to communicate competently within an academic discourse community" [9]; this goes beyond reading and writing and includes presenting, debating and speaking. She also notes that all students will acquire these skills over the course of their study, but that this process can be accelerated with support [9].

2.1. Pedagogical Approaches to Academic Literacy

Challenging the dominant deficit model of academic literacies Lea and Street argued that research into student writing could be considered as a hierarchy of perspective models [8]. The study skills perspective assumes that literacy is a set of atomised skills which can be learned in isolation and transferred to other contexts. The academic socialisation perspective encompasses that of study skills and extends it. Here students are inducted to the new learning 'culture' of university Lea and Street [8]. Students are oriented to a way of learning and the interpretation of learning tasks via conceptual models, Lea and Street [8]. While this approach considers the student as a learner and their social context it assumes a homogeneous culture with norms and practices common across the institution Lea and Street [8]. While departmental and disciplinary differences are acknowledged (e.g., referencing conventions, use of reflective writing in some areas, etc.), the practices of institutional writing including the processes of change and exercise of power are not sufficiently theorised Lea and Street [8]. The Academic Literacies perspective again incorporates atomic skills and socialisation. These are extended to consider academic practices as rooted in institutions (genres, fields and disciplines) each with their own norms and conventions Lea and Street [8]. There is a greater emphasis on the relationship between writing and epistemology encouraging students to see writing as meaning-making and consternation around meaning rather than a skill Lea and Street [8].

The skills approach is still the most widely used approach and often provisioned via generic workshops provided by central Learning Development Units (LDUs) located in the library or students support services [10]. The referral to supporting unit on the periphery of university study often leads to students feeling guilty or stigmatised for their "writing defects" [10].

The academic socialisation and academic literacies models are more connected to the subject domain, which suggests the need for a more collaborative pedagogical approach. Wingate argues that academic literacy must be acquired by all students in context and that as it cannot be provided out of context experts from the community must support this acqui-

sition[9]. Such collaborations have been successful, though the nature of the collaboration is varied. Academic staff may provide examples and support or deliver some aspects of the course[10, 11]. The approach taken here goes a step further; similarities between techniques to support academic writing and the processes, methods and models used to develop software are exploited to provide students with a familiar approach.

Davies outlines a number of stages in the production of an assignment or essay topic (for example "Discuss role of Universities in modern society")[2], and suggests that while most are covered by academic learning advisers the final two are often omitted[1].

The stages outlined by Davies are as follows[1, 2]:

- The deconstruction phase. Here, the student identifies and defines key noun phrases from the given essay question or topic and defines them (e.g., "Role", "University", "Modern Society"). The student also needs to correctly interpret the direction words (e.g., "Discuss").
- The representation phase. Planning the main sections of the body of text to be produced, this will indicate what will be discussed and in what order. Students need to ensure that this covers the key topics and any supporting topics identified in the deconstruction phase.
- The issue phase. Further clarification of issues relating to the key terms (for example, what is "modern" society?) This requires some knowledge from the student and some idea of the evidential support required.
- The research phase. This is the stage where students identify academic support for the points made in the essay. This involves many of the skills introduced by introductory classes to academic practice and those provided by libraries and learning support teams, such as the construction of search statements.
- The argument phase. Students construct an argument drawn from their reading.
- The writing phase. While written assessment takes many forms (e.g. reports, essays, literature reviews, summaries etc.) each requires that the student can clearly articulate the point or issue being presented, though the style may be very different.

There are similarities between this staged model and those used to develop software. A software process is a systematic approach including a sequence of activities that leads to the production of software[12]. Sommerville defines these activities as[13]:

Software Specification, where customers and engineers define the software to be produced and the constraints on its operation.

- Software Design, where the structure of software to be produced is planned out.
- Implementation, where the code of the program is written.
- Software Validation, the software is validated — checked to ensure it does what the customer asked.
- Software Evolution, the system is modified to reflect changing customer requirements.

All software development methodologies (which in this context means "a way of developing a software product") are some combination of the above[14]. However, it is important to note that the activities may be divided, combined, or include details of artifacts produced at each stage, roles and conditions for starting and ending the activities. There are a number of 'very general' or 'generic' models used to discuss the merits of related families of models. Amongst these, the Waterfall model is the simplest, taking each of the key activities themselves borrowed from traditional engineering and putting them in order. Due to the need to cope with changes in the requirements during the development of the system, phased plan-driven approaches such as waterfall have been replaced by more incremental iterative (Agile) approaches[15]. Despite this such models are often used to introduce key concepts and provide a contrast to contemporary methods. Boehm and Turner note that software processes occupy a continuum between plan-driven and Agile approaches, each with a distinct home ground in which they are the most suitable, plan-driven models being well suited to critical systems[16].

The model itself has six phases[14]; in the Requirements Phase, the product concept is explored and refined, and various techniques are used to gather the requirements (what the software must and must not do). In the Analysis Phase, the requirements are analysed and documented using language or models that are as explicit as possible to avoid mistakes. This allows for the planning of future phases in terms of time and resources. The Design Phase is where the plan for the development of the system is documented. This usually entails some notion of Architectural Design (what are the big bits of

the system) and Detailed (or Modular) Design (the bits inside the big bits). The Implementation phase is where the code is written and tested (these activities are often separated with the small bits tested during the coding and the whole system tested at the end). Post delivery maintenance takes place after the software has gone into use. Here we maintain (fix bugs), adapt to change, for example, decimalisation in the 1970s, the millennium bug, etc. Finally, Retirement is when the system is either retired or replaced or made redundant.

The phases are often represented as shown in **Figure 1**, with the output of one stage feeding into the next.

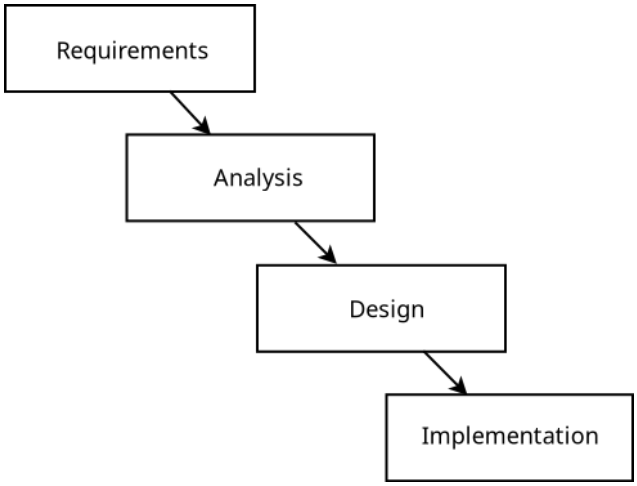


Figure 1. The Waterfall Model.

The software development process is often supported by tools, which include: Tools to support the gathering, organising and modelling of requirements for example the use of Use Case Diagrams and Object Domain Diagrams in the Rational Unified Method (RUP)[17]. Tools to produce models of the problem domain and for the design of the software (e.g., Class Diagrams, Sequence Diagrams, etc., in RUP), tools to support implementation (e.g., Development Environments, Compilers, etc.) and tools to support the verification and validation (e.g., testing frameworks, bug tracking systems, etc.).

As with CASE tools the tools to support academic writing are often specific to a particular phase of the process. Head and Eisenberg list a number of technologies that can support research in general including document annotation (through highlighting in software packages and digital sticky notes) and citation management software[4]. Recommendation software can suggest similar papers to those that research has currently collected[18]. There are general tools which aid collaboration and sharing information through the use of image and document sharing, social bookmarking, forums, Wikis, and social media (such as blogs and micro-blogs)[4]. Online conferencing (text-based) and collaborative texts provide students with an opportunity to make arguments and have them challenged[19]. All of these may be provided within a Virtual Research Environment (VRE)[20].

Tools which support Mind Mapping, such as 'Inspiration' and text-to-speech programs 'Read and Write', while originally targeted at dyslexic students, have been noted as useful to many student writers[7]. Docear is aimed at organising research and provides Mind Mapping capabilities, reference management and a recommendation system[21]. More recently, planTEXT has been developed specifically to aid student writing[22]. Perhaps the most similar to the dedicated case tools for drawing software design diagrams are the CAAM tools used to produce argument maps, which restrict the user to a restricted syntax[1, 2].

Mind Mapping is a graphical technique for modelling information developed in the 1970s by Tony Buzan, who suggested its use for any task requiring thought, planning, recall or creativity[23]. Mind Maps have been used in higher education. Zhang et al. suggest that if students can represent complex relationships between concepts and entities in a diagram, they are more likely to understand, remember and be able to analyse these[24].

Research has shown that Mind Maps can help students organise information[25], promote "deep" learning[26] and require active engagement to produce[27].

The use of Mind Mapping to improve student writing has been explored by a number of researchers in different educational contexts notably teaching English as a Foreign Language (EFL)[25, 28]. Mind Mapping has been shown to increase the detail presented[29, 30], one study highlighting a twofold increase in points of interest[26]. An improvement in the linking and connection of ideas is also noted[29] and that the text produced is better structured[28, 30]. Saed and AL-Omari suggest that the structural improvements are the result of improved organisation of ideas prior to writing[31]. Holland et al. found that students were positive about the use of Mind Mapping as a technique and planned to continue using it[32].

While mind maps tend to focus on the exploration of a single concept, concept maps focus on the relationships

between concepts. Twardy noted while using concept maps to teach critical thinking that several students used the maps to plan their academic writing in other subjects [27]. Concept maps have been deployed to improve both academic papers and literature reviews, primarily for students in the organisation of their research [6, 33]. The concept maps provided a means to discover [6, 33], connect and integrate new concepts [33].

Mind Mapping has been used across educational contexts from postgraduate to secondary school [5, 34]. At a high level to structure whole papers and at a low level for a single paragraph [33, 34]. Diagrams such as the UML class diagram are used at different levels of abstraction during the software development process, to identify Domain Objects at the start of analysis, to suggest a structure in the design phase, and once implementation is complete, to record the design of the completed software [35].

Mind maps promote the sharing of ideas and can be improved through collaboration [31, 36]. There is a strong similarity here with CASE tools, Larman recommends the use UML as a sketch to ensure seminal system features are designed by the whole team [37].

2.2. Pedagogical Intervention

For this study, students were asked to write a literature survey and short research proposal prior to any visualisation technique; these were graded, and students were then given three sessions, each two hours in duration, on utilising mind-maps as a visualisation technique for constructing research proposals. An example of a student Mind Map can be found in **Figure 2**. Participants for this study were enrolled in their second year of their degrees in the following courses: Computer Science, Software Engineering, Business Information System, Artificial Intelligence, Robotics. They had no previous experience of writing research proposals in higher education. With regards to the demographics of the groups, 13 students associated themselves with the gender female, and 110 male, the average age was 21.97, minimum age 18 and maximum 48.

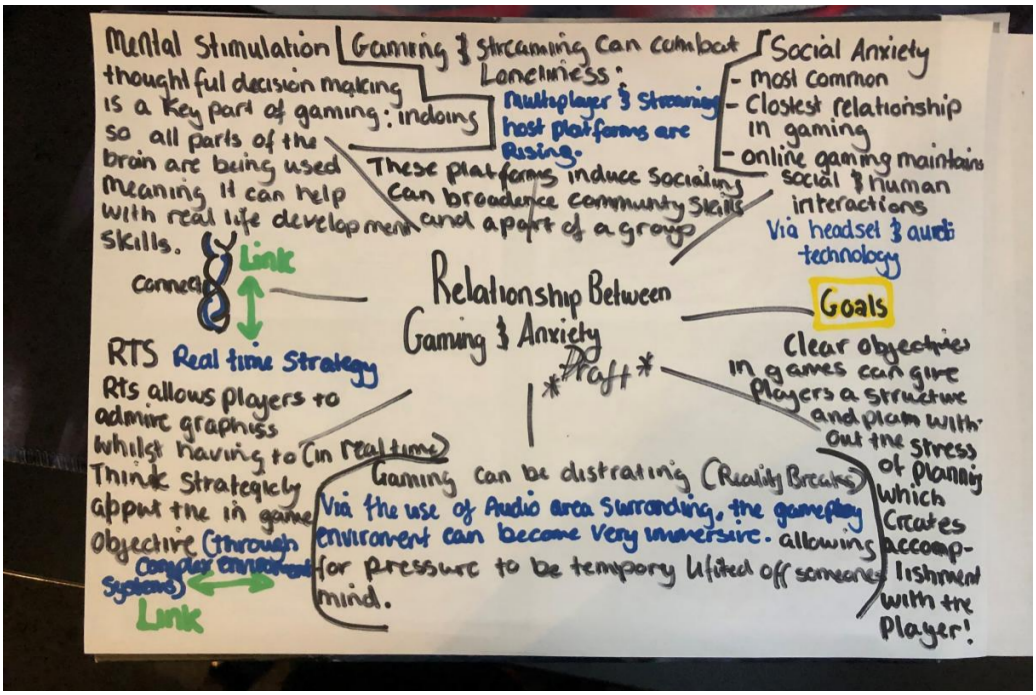


Figure 2. Student Mind Map Example.

Participants first agreed on a research question with the study lead and then were given two sessions of 4 hours in which to complete their mind-maps, prior to writing their research proposal. They were not given directions as to what to include in the mind-maps; they had one class in which an explanation of mind-maps was provided, but were then told they had complete freedom to develop one that they believed would best suit their needs and best reflect their research

question.

3. Survey

Prior to our pedagogical intervention study we asked students to complete a survey to aid in our understanding of their research attitudes, capabilities and limitations. The results to both this survey and the practical study are presented in the next section.

3.1. Mind Map Analysis and Results

A quantitative Mind Map analysis was conducted in order to test our hypothesis of whether such techniques could act as a pedagogical intervention that would aid students in enhancing their literacy skills. For this methodology we looked for evidence of clarity of information transmission by looking for evidence of how ideas and themes were grouped, a hierarchical knowledge pattern as well as multi-layering and hyperlinking within the Mind Map [38, 39].

Our intervention and its analysis provides a step towards providing some context into the efficacy of Mind-mapping as a pedagogical tool for enhancing academic writing skills in students; our aim was to conclude this work with an action-based report as to whether students had improved their Literature Surveying and writing. The measurements for this were literature density and student performance metrics (as decided by 3 independent and experienced academics) and we compared this with previous student work.

Analysis for before and after comparison of Literature Density per student (before and after creation of Mind Maps) was conducted using a 2x2 mixed ANOVA with Bonferroni adjustments made for multiple comparisons. Literature Density for the purposes of this study is defined as the number and depth of sources integrated into students' proposals. Moreover, in our analysis of student performance, which was graded by three independent academic staff. Literature density serves as a proxy for research engagement, indicating the extent to which students were able to identify, interpret, and synthesize scholarly material.

The alpha criterion used for the analyses was $p<0.05$; the dependent variable was the percentage improvement from before and after Mind Maps. The same technique was used to understand whether there was improvement in student performance. Student performance provides a convenient uniform measure of performance improvement and this allowed us to make a comparison within a single, conservative analysis, and the same was true for our literature density analysis, and therefore we felt no need to convert either before conducting our analyses. There was a clear effect of the intervention ($p = 0.0396$) indicating that the overall size of improvement was statistically significant.

The full picture for the ANOVA result can be found in **Table 1**. Moreover, participation on creation of the Mind Maps was optional and we also have results for students that did not create Mind Maps prior to writing their proposal, results rule out improvement simply due to repeating the exercise, as those that did not create the Mind Map showed no improvement, namely the ANOVA for those students returned a p value of 0.82 which is very high, and F-critical of 3.91.

Our survey was conducted with a standard scoring of opinions and the survey (percentages at each opinion scoring) results can be found in the **Table 2**, we found that most participants strongly agreed on the importance of research to them personally and mostly agreed on its level of interest, however, rather worrying most believe it is possible to conduct research without fully understanding the domain they are researching, this is where thought structuring activities such as mind-map can aid in focusing the work towards a sub-domain that is graspable to the individual student.

Table 1. Anova.

Groups	**Count**	**Sum**	**Mean (2 d.p.)**	**Variance (2 d.p.)**		
Before Intervention	103	6,803	66.05	403.52		
After Intervention	103	6,186	60.06	458.06		
Source of Variation	SS (2 d.p.)	df (2 d.p.)	f (2 d.p.)	MS (2 d.p.)	P-value (2 d.p.)	F Critical (2 d.p.)
Between Groups	1,848.00	1	1,848.0	4.29	0.40	3.89
Within Groups	87,880.41	204	430.79			
Total	89,728.41	205				

Table 2. Survey Table: Attitudes towards Research, in Percentages.

Question	Strongly Agree	Agree	Neither Dgree nor Disagree	Somewhat Disagree	Strongly Disagree
Understanding research is important to me	56.25	37.50	3.13	0.00	3.13
Research is interesting	31.25	50.00	12.50	6.25	0.00
I find research difficult	9.38	37.50	31.25	12.50	9.38
I'm looking forward to conducting independent research	21.88	56.25	12.50	6.25	3.13
It is possible to conduct research without fully understanding the domain I'm researching	18.75	40.63	21.88	12.50	6.25

3.2. Attitudes towards Literature Reviewing and Mind Maps

With regards to literature reviewing, students were quite divided as to whether they believe they know what constitutes a good literature review, most were confident in their knowledge of what peer-review means yet were not able to distinguish between an academic conference proceeding or a journal, and most had never downloaded an academic paper and read it, nor could they understand what metrics are used to judge academic literature; this suggest students confidence in what is "peer review" and a good literature survey is not matched by the reality of their knowledge up to when the survey was taken. Full results are as follows:

I understand what constitutes a good literature review.

- Strongly agree 6.25%
- Agree 34.38%
- Neither agree nor disagree 34.38% Somewhat disagree 21.88%
- Strongly disagree 3.13%

Are you familiar with Google Scholar?

- Yes 53.13%
- No 46.88%

In your studies do you often read the recommended book?

- Yes, often 0.00%
- Sometimes 62.50%
- No, never 37.50%

Do you know what we mean by peer-reviewed?

- Definitely not 0.00%
- Probably not 3.13%
- Might or might not 9.38%
- Probably yes 34.38%
- Definitely yes 53.13%

Do you know the difference between an academic journal and a conference proceeding?

- Definitely not 31.25%
- Probably not 31.25%
- Might or might not 18.75%
- Probably yes 15.63%
- Definitely yes 3.13%

In addition to the results below, we found that only 6.25% answered yes to the question of whether they had ever downloaded an academic journal and read it, and 93.75% answered they had not. The percentages for the question whether they had ever read a conference proceeding were exactly the same. When asked to elaborate if answered yes one participant said "I have previously downloaded papers from conference proceedings regarding what I want to do my dissertation and this topic on previously, as it is something I actively research in real life as I have been investing in the tech since 2016". Finally, 84.38% were not aware of how to judge an academic journal for its validity and 15.63% believed they would be.

With regards to Mind Maps, 65.63% answered they had created a Mind Map before and the remaining had not, 56.25% felt unsure as to whether this Mind Map exercise would aid them in developing better research proposal, 37.50% felt it definitely would and 6.35% would not.

The statistical analysis just presented is complimented by an additional investigation that looked for semantic structures within Mind Maps.

4. Discussion

We found that 57.8% of Mind Maps had three or more ideas/themes grouped; 34.6% of Mind Maps had a hierarchical knowledge pattern; and only 10.1% of Mind Maps used multi-layering and hyperlinking. That suggests that even without high complexity in the final Mind Map, mere engagement with the process can aid students in produce better literature surveys. For further work we will investigate further lessons in Mind Mapping so the latter are produced at a higher level of complexity by students, whether this will have even more pronounced results in enhancing pupil's academic writing skills.

Both the practical intervention and the survey are limited to students enrolled in technology degrees, there is a known and vast cultural difference across disciplines, and we make no claim of applicability of our methodology beyond our own discipline.

However, we would like to investigate to which extend this can be applied to other fields, if at all and have included this in our future research plans. Furthermore, it must be noted that successful and ambitious students tend to take advantage of additional support [40], weaker students struggling with the burden of the curriculum do not, so this must be taken into account when considering the students who did and did not construct a Mind Map prior to writing the second version of the research proposal.

Our results indicate that the use of mind maps led to statistically significant improvements in both literature density and student performance. These findings are consistent with prior research that highlights the benefits of mind mapping for academic writing, particularly in terms of organization and idea development. For instance, [29] observed that mind mapping significantly increased the detail and depth of content produced by EFL students, with a notable rise in points of interest included in written work. Similarly, our participants demonstrated a marked improvement in the integration of scholarly sources, reflecting not just increased citation volume, but also more coherent synthesis of ideas. This suggests that mind mapping facilitates deeper engagement with source material, even in a technical context such as computing.

Our results also align with findings of Al-Jarf[30], which showed that the use of mind-mapping software led to better structured essays among freshman students. In our case, post-intervention submissions exhibited clearer argumentative flow and more balanced word distribution across sections—indicating improved planning and structural awareness. While Al-Jarf focused on EFL learners and basic writing skills [30], our findings extend the relevance of mind mapping to higher-order academic tasks such as research design and proposal development.

5. Conclusions

It has been observed that students use their maps to organise their research (concepts and ideas) and structure their writing. In some cases as with the Object Domain Model and Class Diagram in UML there is a great deal of similarity between these two models. The hypothesis that Mind Maps can be used as an intermediary tool to aid in composing literature landscapes. This has been confirmed in our investigations, within our limited scope described in the previous sections. We presented the results from our survey, which showed varying attitudes of students towards academic research. Moreover, our practical intervention involved mind-mapping their research proposals prior to writing their literature reviews and full research proposals. Our practical intervention has been statistically shown to be satisfactory.

It is important to note that participation in the mind map creation exercise was optional. This introduces a potential source of bias, as more motivated and academically engaged students may have been more likely to participate. Consequently, the observed improvements in literature density and performance metrics may reflect differences in baseline motivation and academic behavior rather than the intervention itself, as noted results could be skewed [40]. However since our focus was on the improvement per baseline of individual students rather than the whole cohort, having only more motivated students still showing an improvement validates the pedagogical intervention.

For future work, we plan to co-design and pilot a school-based academic-writing support programme in close partnership with our campus library. Drawing on the specialist knowledge of subject librarians to design a series of interventions [9, 10]; with a view to expand this to other faculties and departments finding suitable domain specific activities to map to the academic writing process.

Looking further ahead, we will explore the integration of immersive Virtual Reality (VR) environments to enhance complex data visualisation and deepen students' engagement with multi-dimensional datasets[41].

Finally, Wingate notes that many approaches focus on the later stages of presentation (i.e., writing) rather than the stages before[9]. This chunk of our research has the same flaw, though the maps we propose are useful both in the organisation of research and planning of writing. The next phase of this project will look to address this towards the development of a methodology (with processes, tools and techniques) for academic writing within the school.

Author Contributions

A.C. and G.J. developed the hypothesis that Mind Maps could serve as an intermediary tool to enhance the composition of literature landscapes for undergraduate computing students. Their contributions encompassed the design and execution of the research methodology, which included an initial survey to understand student attitudes towards academic research and a subsequent practical intervention. This intervention involved students mind-mapping their research proposals prior to writing their literature reviews and full research proposals.

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of Cardiff Metropolitan University (January 2023).

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

Raw data is stored in a repository which will be shared with researchers who request access to any of the authors; provided their intentions are to conduct further analyses, similar investigations, that no financial gain is made from the data, and that the present work is referenced. This work followed our institution's strict ethical guidelines and ethical approval was obtained from Cardiff Metropolitan University and the participants, which included informed consent, confidentiality and responsible research practice. The authors have no conflict of interest to report for this work.

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Conflicts of Interest

The authors declare no conflict of interest.

References

[1] Davies, W.M., 2008. Note quite right: Teaching students how to make better arguments. Teaching in Higher Education. 13(3), 327–340. DOI: https://doi.org/10.1080/13562510802045352

[2] Davies, W.M., 2011. Concept mapping, mind mapping and argument mapping: What are the differences and do they matter? Higher Education. 62(3), 279–301.

[3] Head, A.J., 2007. Beyond Google: How do students conduct academic research? First Monday. 12(8), 1–10. DOI: https://doi.org/10.5210/fm.v12i8.1998

[4] Head, A.J., Eisenberg, M.B., 2010. Truth Be Told: How College Students Evaluate and Use Information in the Digital Age. Project Information Literacy Progress Report: "Truth Be Told". 1 November 2010. The Information School, University of Washington: Seattle, WA, USA. pp. 1–72. DOI: http://dx.doi.org/10.2139/ssrn.2281485

[5] Torrance, M., Thomas, G.V., Robinson, E.J., 1994. The writing strategies of graduate research students in the social sciences. Higher Education. 27(3), 379–392.

[6] Alias, M., Suradi, Z., 2008. Concept mapping: A tool for creating a literature review. In Proceedings of the Third International Conference on Concept Mapping, Tallinn, Estonia & Helsinki, Finland, 22–25 November 2008; pp. 96–99.

[7] Ganobcsik-Williams, L., 2002. A Report on the Teaching of Academic Writing in UK Higher Education. Royal Literary Fund: London, UK. pp. 1–50.

[8] Lea, M.R., Street, B.V., 1998. Student writing in higher education: An academic literacies approach. Studies in Higher Education. 23(2), 157–173.

[9] Wingate, U., 2018. Academic literacy across the curriculum: Towards a collaborative instructional approach. Language Teaching. 51(3), 349–364. DOI: https://doi.org/10.1017/S0261444816000264

[10] Calvo, S., Celini, L., Morales, A., et al., 2020. Academic literacy and student diversity: Evaluating a curriculum-integrated inclusive practice intervention in the United Kingdom. Sustainability. 12(3), 1155. DOI: https://doi.org/10.3390/su12031155

[11] Chiu, Y.L.T., Rodríguez-Falcón, O., 2018. Embracing diversity for attainment: An inclusive approach to the teaching of academic literacy. Journal of Academic Writing. 8(2), 36–47.

[12] Sommerville, I., 2011. Introduction. In: Sommerville, I. (ed.). Software Engineering, 9th ed. Addison Wesley: Boston, MA, USA. pp. 3–27.

[13] Sommerville, I., 2011. Software processes. In: Sommerville, I. (ed.). Software Engineering, 9th ed. Addison Wesley: Boston, MA, USA. pp. 27–55.

[14] Schach, S.R., 2007. The scope of object-orientated software engineering. In: Schach, S.R. (ed.). Object-Oriented Software Engineering, 1st ed. McGraw-Hill: New York, NY, USA. pp. 3–31.

[15] Sommerville, I., 2011. Agile software development. In: Sommerville, I. (ed.). Software Engineering, 9th ed. Addison Wesley: Boston, MA, USA. pp. 56–81.

[16] Boehm, B., Turner, R., 2003. Observations on balancing discipline and agility. In Proceedings of the Agile Development Conference, Salt Lake City, UT, USA, 25–28 June 2003; pp. 32–39.

[17] Kruchten, P., 2003. The Rational Unified Process: An Introduction, 3rd ed. Addison-Wesley: Boston, MA, USA. pp. 1–300.

[18] Beel, J., Gipp, B., Langer, S., et al., 2016. Research-paper recommender systems: A literature survey. International Journal on Digital Libraries. 17(4), 305–338. DOI: https://doi.org/10.1007/s00799-015-0156-0

[19] Bradshaw, Y.J., 2012. Open education resources and higher education academic practice. Available from: https://oro.open.ac.uk/37389/19/Bradshaw%20Younie%20Jones%20CWIS%20submitted%20v2.pdf

[20] Wilson, A., Rimpiläinen, S., Skinner, D., et al., 2007. Using a virtual research environment to support new models of collaborative and participative research in Scottish education. Technology, Pedagogy and Education. 16(3), 289–304.

[21] Beel, J., Gipp, B., Langer, S. et al., 2011. Docear: An academic literature suite for searching, organizing and creating academic literature. In Proceedings of the 11th ACM/IEEE Joint Conference on Digital Libraries, Ottawa, Canada, 13–17 June 2011; pp. 465–466. DOI: https://doi.org/10.1145/1998076.1998188

[22] Lopes, S.F., Castro, R., Arajo, S., 2018. A mind-mapping front-end for text writing. In Proceedings of the 2018 IEEE 16th International Conference on Industrial Informatics, Porto, Portugal, 18–20 July 2018; pp. 1–6. DOI: https://doi.org/10.1109/INDIN.2018.8472047

[23] Buzan, T., 1983. Use Both Sides of Your Brain, 2nd ed. EP Dutton: New York, NY, USA. pp. 1–150.

[24] Zhang, Y.L., Xiao, S.J., Yang, X.B., et al., 2010. Mind mapping based human memory management system. In Proceedings of the 2010 International Conference on Computational Intelligence and Software Engineering, Wuhan, China, 10–12 December 2010; pp. 1–4. DOI: https://doi.org/10.1109/CISE.2010.5676752

[25] Abdullah, A., Köylü Baydemir, S.E.K., 2017. A systematic review of research on mind mapping in EFL context. Journal of Social Humanities Sciences Research. 4(14), 1801–1811. DOI: https://doi.org/10.26450/jshsr.252

[26] Mahmud, I., Rawshon, S., Rahman, M.J., 2011. Mind map for academic writing: A tool to facilitate university level students. International Journal of Educational Science and Research. 1(1), 21–30.

[27] Twardy, C., 2004. Argument maps improve critical thinking. Teaching Philosophy. 27(2), 95–116.

[28] Naghmeh-Abbaspour, B., Rastgoo, V., 2020. Analysis to find out the effect of mind mapping technique on the writing skills of Iranian learning of English as a Foreign Language. Texto Livre. 13(2), 102–116. DOI: https://doi.org/10.35699/1983-3652.2020.24559 (in Portuguese)

[29] Bukhari, S.S.F., 2016. Mind mapping techniques to enhance EFL writing skill. International Journal of Linguistics and Communication. 4(1), 58–77.

[30] Al-Jarf, R., 2009. Enhancing freshman students' writing skills with a mind-mapping software. Conference proceedings of »eLearning and Software for Education« (eLSE). 5(1), 375–382.

[31] Saed, H.A., Al-Omari, H.A., 2014. The effectiveness of a proposed program based on a mind mapping strategy in developing the writing achievement of eleventh grade EFL students in Jordan and their attitudes towards writing. Journal of Educational Practice. 5(18), 88–109.

[32] Holland, B., Holland, L., Davies, J., 2004. An Investigation into the Concept of Mind Mapping and the Use of Mind Mapping Software to Support and Improve Student. CELT Learning and Teaching Projects 2003/04. University of Wolverhampton: Wolverhampton, UK. pp. 1–30.

[33] Pribaldi, B.A., 2018. Use of the concept mapping strategy to improve academic writing. In: Persichitte, K. A., Suparman, A., Spector, M. (eds.). Educational Technology to Improve Quality and Access on a Global Scale. Springer: Cham, Switzerland. pp. 273–285.

[34] Wangmo, T., 2022. Implementation of digital mind mapping tools to improve academic reading and summary writing. Journal for Research Scholars and Pro-

fessional of English Language Teaching. 6(33), 1–18. DOI: https://doi.org/10.54850/jrspelt.6.33.002

[35] Larman, C., 2014. Requirements to design - iteratively. In: Larman, C. (ed.). Applying UML and Patterns, 3rd ed. Prentice Hall PTR: Upper Saddle River, NJ, USA. pp. 131–172.

[36] Kwon, S.Y., Cifuentes, L., 2009. The comparative effect of individually-constructed vs. collaboratively-constructed computer-based concept maps. Computers & Education. 52(2), 365–375. DOI: https://doi.org/10.1016/j.compedu.2008.09.012

[37] Larman, C., 2014. Iterative, evolutionary, and agile. In: Larman, C. (ed.). Applying UML and Patterns, 3rd ed. Prentice Hall PTR: Upper Saddle River, NJ, USA. pp. 17–41.

[38] Kress, G., Van Leeuwen, T., 2018. Reading Images: The Grammar of Visual Design, 2nd ed. Routledge: London, UK. pp. 1–300.

[39] Mavers, D., Somekh, B., Restorick, J., 2002. Interpreting the externalised images of pupils' conceptions of ICT: Methods for the analysis of concept maps. Computers & Education. 38(1–3), 187–207.

[40] Durkin, K., Main, A., 2002. Discipline-based study skills support for first-year undergraduate students. Active Learning in Higher Education. 3(1), 24–39. DOI: https://doi.org/10.1177/1469787402003001003

[41] Beltra, F., 2022. Comparing the quality of business decisions supported by alternative visualization platforms. In Proceedings of the UKSim-AMSS 24th International Conference on Modelling and Simulation, Cambridge, UK, 13 April 2022; pp. 1–7. DOI: https://doi.org/10.5013/IJSSST.a.23.01.01