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Computing projects framework for undergraduate research: based on teaching experience in Kenya and supported by existing literature.

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Abstract

This paper outlines the guidelines and requirements for students undertaking a computing project as part of their academic program. The project is a critical component of most undergraduate programs and is designed to provide students with the opportunity to apply theoretical knowledge to practical scenarios, demonstrating their ability to plan, execute, and present a complex piece of work. Unfortunately, there is currently a lack of clear and helpful guidance on how to conduct elementary research at this level, differentiate a computing project from other types of projects, and report it effectively. This paper aims to assist both computing students and faculty in carrying out and reporting on final-year research projects. It documents the differences in research approaches across various computing disciplines and provides a guiding framework for faculty overseeing the undergraduate research process. The guidelines cover various aspects of the project process, including the development of a project proposal, conducting the research, and writing the final report. It emphasizes the importance of early planning, regular supervision, and adherence to academic standards, particularly in the presentation and documentation of the project work. Additionally, the document details the criteria for project assessment, highlighting the need for clarity, innovation, and rigor in both the practical and written components of the project. Instructions on the submission process and the responsibilities of students and supervisors throughout the project lifecycle are also included.

Keywords: Computing, Research Projects, Software Applications, Project Development, Assessment Criteria

1. Introduction

The origins of computer science are deeply rooted in mathematics, engineering, and commercial practice. Early mathematical concepts, such as algorithms and logic, provided the theoretical foundation for modern computation, with key contributions from George Boole's Boolean algebra and Alan Turing's concept of the Turing machine, which laid the groundwork for systematic problem-solving in computing (Gleick, 2011; Hodges, 2014). Engineering played a critical role in transforming these abstract ideas into practical machines, with pioneers like Charles Babbage and John von Neumann bridging the gap between theory and hardware, leading to the creation of early computers like the ENIAC during World War II (Swade, 2000; Goldstine, 1993). Additionally, the commercial need for efficient data processing drove the development of business-oriented computers, such as IBM's punched card machines, eventually leading to the widespread adoption of personal computers, which solidified computer science as a distinct and essential field (Campbell-Kelly, 2003; Ceruzzi, 1998).

Computing has generally speaking evolved into five distinct areas. First is computer science which remains the core field, focusing on algorithms to process and communicate information, covering both practical aspects like programming languages and theoretical areas such as complex

computational theory and very large-scale integration (VLSI) (Shannon, 2020). Information Systems emphasizes the acquisition, formatting, storage, and retrieval of information, with a particular focus on the interaction between computer systems and the people who manage them, making it more business-oriented compared to other computing fields (Bourgeois, 2021). Information Technology deals with both software and hardware components, encompassing activities related to the creation, exchange, access, and security of digital data (Ceruzzi, 2019). Software Engineering is dedicated to the systematic design, development, and maintenance of software, combining principles from computer science and engineering to produce reliable and efficient systems (Pressman, 2022). Finally, Computer Technology focuses on the hardware aspects of computing, involving the design, development, and optimization of physical computing devices, thus bridging the gap between engineering and computing to enhance hardware performance and capabilities (Hennessy & Patterson, 2021).

Curricula for computing qualifications in Higher Education Institutions (HEIs) mandate that students must pass both written examinations and a computing project. This project, which can cover any area of computing, allows students to explore topics of personal interest, provided it is recommended by a supervisor and approved by the Faculty Board. The main goal of the project is to enable students to apply theoretical knowledge to practical scenarios, thereby bridging the gap between academic learning and real-world application (Jones & Smith, 2022; Williams et al., 2021).

The objectives of a computing project are multifaceted, offering students the opportunity for deep exploration into specific areas of interest, thereby enhancing their understanding of key computing topics. These projects serve as a platform for demonstrating the ability to integrate and apply complex concepts within computer systems, reinforcing theoretical knowledge through practical application. Additionally, by tackling complex computing problems, students develop crucial skills in self-organization, project planning, and management, gaining valuable hands-on experience from inception to completion. Moreover, these projects encourage innovation in Information and Communication Technology (ICT), fostering creative thinking and the development of original solutions to real-world challenges (Nguyen & Brown, 2022; Smith et al., 2021).

When writing a project proposal, it is essential to begin with a well-defined title that succinctly captures the essence of the research. The title serves as the first point of contact between the researcher and their audience, offering a glimpse into the project's focus. A strong title should be specific, reflecting the main theme of the research while avoiding overly broad or vague language. It sets the tone for the entire proposal and should align with the objectives and outcomes of the study. As such, considerable thought and precision are required when selecting a title, as it plays a crucial role in attracting the interest of reviewers and potential stakeholders.

The introduction section of the proposal provides an overview of the research topic, establishing the context and significance of the study. This section should highlight the relevance of the research within the broader field, outlining the key issues or gaps that the study aims to address. The introduction should also provide a brief background, summarizing the existing knowledge and recent developments related to the topic. It is important to articulate the research question or hypothesis clearly, as this sets the stage for the problem definition. The introduction acts as a roadmap for the reader, guiding them through the rationale behind the study and its intended contributions.

The problem definition is a critical component of the project proposal, as it precisely identifies the specific issue or challenge that the research will tackle. This section should be detailed, offering a clear explanation of why the problem is significant and the impact it has within the field of study. The problem definition must be framed in a way that underscores the necessity for research, making a compelling case for why this issue deserves attention. Following the problem definition, the project justification explains why the proposed research is the appropriate approach

to address the problem. This section should demonstrate the uniqueness and value of the research, highlighting how it will contribute to existing knowledge or provide practical solutions.

A thorough literature survey is essential to situate the proposed research within the existing body of work. This section should review relevant studies, theories, and models, identifying gaps that the current research intends to fill. The literature survey not only informs the research design but also validates the need for the study by showing what has been done and what remains unexplored. The research methods section outlines the approach and techniques that will be employed to conduct the study, including data collection and analysis methods. Additionally, the proposal must include a budget that details the resources required for the project, ensuring that all necessary materials, tools, and personnel are accounted for. Finally, a project schedule should be presented, breaking down the research activities into manageable phases with specific timelines, ensuring that the project remains on track and is completed within the stipulated period.

2. The Research Project Key Players

The success of a research project is largely dependent on the collaboration and expertise of three key players: the researcher, supervisor(s), and evaluator(s). Each plays a distinct role in the research process, contributing to the project's overall quality and outcome. The researcher is primarily responsible for conducting the study, from gathering and analyzing data to presenting the findings. They bring their knowledge and skills to bear on the research question, driving the project forward. Supervisor(s) act as mentors, offering critical guidance throughout the research process, helping to refine the research design, methodology, and interpretation of results. Evaluator(s), usually an independent panel, assess the completed work's quality and rigor, ensuring it meets academic standards and offering constructive feedback. Together, these key players form a collaborative network essential for the successful execution and evaluation of a research project (Mullen, 2016; Lee & Murray, 2015).

The researcher’s role is multifaceted, requiring a balance of independence and collaboration with the supervisor. Establishing a clear and mutually agreed-upon supervision and work schedule is critical, aligning with both parties' availability and expectations (Boud & Lee, 2009). Early discussions on the research topic and timeline are vital for setting the project on the right course. Once the schedule is established, the researcher must adhere to it and maintain regular communication, ensuring they remain visible and engaged with their supervisor throughout the project. Keeping systematic records of the research process is essential for tracking progress and providing a clear documentation trail. Additionally, researchers should submit written material well in advance to allow sufficient time for supervisory feedback, which is crucial for refining the work. The researcher must also consider the supervisor's criticisms and guidance seriously, as this feedback is vital for improving the research quality. Operating within legal and ethical boundaries is paramount, and the researcher must proactively communicate any issues to the supervisor. Ultimately, while the supervisor provides guidance, the researcher drives the project and is responsible for its direction and success (Fitzgerald & White, 2012).

Supervisors play an integral role in the research project, ensuring that the research is conducted effectively and in adherence to the necessary academic standards. They must be thoroughly familiar with the rules and standards of the organization and ensure that their supervisees are equally well-informed. This involves clear communication about expectations, guidelines, and deadlines that govern the research process (Wisker, 2012). Supervisors should engage in discussions with the researcher to agree on dates and work schedules, ensuring mutual understanding of timelines and milestones. Their guidance is crucial in helping the researcher navigate challenges and refine their work, providing expertise and feedback that are essential to the research's success. To remain effective in their roles, supervisors must continuously update their skill sets, staying current with developments in their field and research methodologies. Regularly scheduled meetings are essential for maintaining consistent communication, tracking

progress, and addressing any emerging issues promptly (Gatfield, 2005).

Evaluators play a crucial role in providing an objective and thorough assessment of the completed research work. Their evaluation is based on several key criteria, including the research's contribution to the field, the complexity of the problem addressed, the practicality of the proposed solution, and the overall presentation style (Knight & Steinbach, 2008). The evaluation process is intended to be impartial, focusing solely on the research's merits rather than any external factors, ensuring that the assessment is fair and reflective of the work's quality and impact. Evaluators' feedback is critical as it often influences the academic outcome and the potential for further development or application of the research. Their objective review helps ensure that the research meets the required standards for academic excellence, thus playing a vital role in determining the project's success and its value to the broader academic community (Weaver et al., 2006).

3. How to Develop Key Aspects of the Project

This section provides guidance on the development of key components essential for the initial stages of a research project, including the project title, abstract, problem statement, research objectives, and justification. These elements are critical in framing the scope and direction of the project, ensuring that it is well-defined and grounded in a clear research purpose. Additionally, this section offers insights into how to effectively craft each component, helping students articulate their research focus and objectives in a coherent and compelling manner. The subsequent sections of the research, which constitute the main chapters of an undergraduate project report, are thoroughly discussed in a different section titled "Presentation of the Project Report" under the subheading "Report Format." This latter section delves into the structure and organization of the entire report, guiding students on how to present their findings and analysis in a clear, logical, and academically rigorous format.

3.1 Project Title

When developing a title for an academic paper, selecting keywords that will engage the target audience and ensure effective indexing by literature-scanning services is crucial. Placing these keywords at the beginning of the title enhances visibility and impact, making the title more likely to attract readers and be discovered by relevant audiences. Utilizing techniques like a colon or dash to separate a keyword-rich phrase from a secondary explanatory section can further refine the title's focus and clarity (Jamali & Nikzad, 2011; Hartley, 2014).

A well-crafted title is essential as it sets the reader's expectations and conveys the project's essence. It should indicate the application being developed and should be concise, specific, and informative, avoiding unnecessary filler words and ensuring that the chosen keywords accurately reflect the paper's content and significance. Avoiding abbreviations, jargon, and proprietary names is important to prevent confusion. By carefully considering grammar, word order, and keyword inclusion, researchers can create a title that effectively represents their work and enhances its discoverability within the academic community (Swales & Feak, 2012; Day & Gastel, 2012).

3.2 The Abstract

An abstract serves as a concise summary of the information in a document, often being the first and sometimes the only part of a manuscript that is read. Therefore, it is crucial that the abstract is written clearly and succinctly, providing a brief overview of each of the main sections of the paper—Introduction, Methods, Results, and Discussion (IMRAD). The abstract should articulate the principal objective and scope of the investigation, describe the methods used, summarize the key results, and state the main conclusions. It is generally easier to write the abstract after completing the paper, as this allows the writer to accurately reflect the content. The abstract should be kept within 250 words, written in one paragraph, and in the past tense since it refers to work that has already been completed. It should avoid citing references and must be consistent with the figures and information presented in the main text (Day & Gastel, 2012).

Given that the abstract may be the only part of the manuscript that many readers will see, it must be able to stand alone as a summary of the work. It

should include a well-defined purpose and hypothesis, clearly detailing the materials and methods, results with actual data and appropriate metrics, and a conclusion that follows directly from the methods and results. The conclusions should not simply reiterate the results but should be justified by the data and analysis provided, without overstating the findings, particularly if the study is based on a small sample size. The abstract should avoid vague objectives and instead mirror the specific goals outlined at the end of the Introduction. By following these guidelines, the abstract can effectively convey the essence of the research, ensuring that it captures the reader's attention and accurately represents the content of the paper (Hartley, 2014; Swales & Feak, 2012).

3.3 Problem Statement

The problem statement for an undergraduate research project should clearly define the gap that the project aims to address, providing context and justification for the problem's significance. For example, a student might explore the challenges in today's fast-paced digital environment within a specific industry or field that relies heavily on efficient data management and user-friendly interfaces to ensure smooth operations and enhance user experience. The student can identify gaps, such as existing software solutions in this area being outdated, lacking critical features, or being too complex for the average user, which leads to inefficiencies and user frustration. These identified gaps in the market create a need for a more intuitive, streamlined software solution that meets the specific needs of a particular target audience, such as small businesses, educational institutions, healthcare providers, or others (Pressman, 2014; Sommerville, 2016).

The problem statement can be concluded with a statement like, "This project seeks to address this issue by developing software, such as a web-based application or mobile app, that not only simplifies the specific task or process but also integrates key features or functionalities to improve overall user efficiency and satisfaction. The software will be designed with user experience at its core, ensuring that it is accessible, easy to use, and meets the specific needs of its intended audience. By tackling the limitations of current solutions, this project aims to provide a practical tool that can significantly enhance productivity and user engagement in the specific industry or field" (Nielsen & Budiu, 2012; Cooper et al., 2014).

3.4 Research Project Objectives

The objectives for a computing undergraduate project are structured to systematically address key phases of software development, ensuring a comprehensive and methodical approach to the project. The general objective involves mapping the project's title into an actionable verb, which encapsulates the overall goal of the project. This general objective is then broken down into specific, actionable steps. The first specific objective is centered on problem definition and requirement analysis. This initial phase is crucial as it involves identifying the core problem that the project aims to address and conducting a detailed analysis to determine all necessary requirements. These requirements include understanding user needs, identifying potential inputs, defining processing requirements, and establishing the expected outputs (Pressman, 2014). This phase lays the foundation for the entire project by ensuring that the scope and objectives are clearly understood and well-defined.

The second objective focuses on the development of the application, encompassing both the design and coding stages. During the design phase, the system's architecture is created based on the previously identified requirements. This stage is critical as it translates theoretical requirements into a practical blueprint for the application. Following the design phase, coding is undertaken to bring the application to life, where the logical structure developed during design is implemented in the chosen programming language(s) (Sommerville, 2016). The coding phase requires careful attention to detail to ensure that the application is both functional and efficient, adhering to the design specifications.

The final specific objective involves testing the developed application. This phase is essential to ensure that the application functions as intended, meets all specified requirements, and is free from significant bugs or issues. Testing typically involves various strategies, such as unit testing, integration testing, and user acceptance testing, each designed to verify different aspects of the

application (Myers, Sandler, & Badgett, 2011). Through rigorous testing, any flaws or discrepancies can be identified and rectified, ensuring the final product is robust, reliable, and ready for deployment. This structured approach to defining objectives not only ensures that each phase of the project is thoroughly planned and executed but also increases the likelihood of producing a high-quality software solution that effectively addresses the problem at hand.

3.5 Justification

The justification for a computing undergraduate software project typically provides a compelling rationale for why the project is necessary and valuable. It begins by outlining the specific problem or gap in the current solutions that the project aims to address, emphasizing the significance of the issue within its relevant context, such as a particular industry, organization, or user group. The justification should highlight the limitations of existing software solutions, such as inefficiencies, lack of specific features, or user experience challenges, and explain how the proposed project will overcome these shortcomings. Additionally, the justification may include a discussion on the potential benefits and impact of the project, such as improving productivity, enhancing user satisfaction, or introducing innovative features that offer a competitive advantage. This section is crucial as it demonstrates the project's relevance, aligns it with broader objectives, and provides a clear argument for why the project is worth pursuing, ultimately guiding the scope and direction of the development effort (Pressman, 2014; Sommerville, 2016).

4. Presentation of the Project Report

4.1 Report Appearance

A high standard of organization and presentation is crucial in a report, as it significantly impacts the evaluation and overall grade. The report should be concise, providing an adequate description of the work undertaken without unnecessary length. It is essential that the report is written in clear and correct English, as reports that are poorly structured or riddled with spelling and grammatical errors are likely to be returned for rewriting or may receive a lower grade (Day & Gastel, 2012). Each paragraph should focus on one major idea, with paragraphs indented and lines skipped between them. Frequent use of headers helps in organizing the content effectively, making it easier for the reader to follow the report's structure.

In terms of formatting, most universities require reports to be printed on one side of A4 paper with specific margin requirements, such as 35mm on the binding edge and 15mm elsewhere. All pages should be numbered, typically using a format like "page x of y," depending on institutional guidelines. The selection of font, size, and line spacing (commonly 1.5 with full justification) is often dictated by the university’s standards, with Times Roman being a popular choice for the main text (Swales & Feak, 2012). Headers generally contain the title of the project, and footers include the page number, contributing to a polished and professional presentation.

4.2 Report Format

The report format for a research project includes several key sections that structure the document and ensure comprehensive coverage of the work undertaken. It begins with preliminary which includes a cover page, followed by a declaration of originality, an abstract summarizing the research, and acknowledgments. A table of contents, along with lists of figures, tables, and abbreviations, provides a navigational guide. In the main body of the report are five chapters: introduction, literature review, methodology, results, and discussion. Further the references are compiled at the end of the report, adhering to a consistent citation style and appendices which include user manuals, sample programs, and other technical documentation such as critical codes.

The Introduction, which is Chapter One, serves as the foundation of the research project, providing a comprehensive overview of the study's background and setting the stage for the work that follows. This chapter begins by describing the current state of knowledge in the field, offering a summarized review of relevant literature, theories, and previous research to establish the context for the study (Maxwell, 2013; Creswell, 2014). It identifies gaps, inconsistencies, or unresolved

issues in the existing body of knowledge that the research aims to address (Lee & Lee, 2015). The introduction also clearly articulates the research question or hypothesis that guides the study, framing it within the broader academic and practical landscape (Smith & Kosslyn, 2007). Additionally, this chapter outlines the specific aims and objectives of the research, explaining the intended contributions to the field and the significance of the work (Johnson & Johnson, 2009). By situating the research within its academic and practical context, the introduction not only justifies the need for the study but also provides the reader with a clear understanding of the research's scope, direction, and potential impact (Yin, 2018).

The second chapter is literature review, an important component of any research process, as it involves discussing relevant previous work and appropriate literature to establish the foundation for the study (Boote & Beile, 2005). The primary objectives of a literature review include effectively searching for pertinent literature, providing a comprehensive overview of existing knowledge, and identifying gaps that the research aims to address (Hart, 1998). This process extends beyond simple summarization; it involves critically evaluating each source to assess its strengths, weaknesses, and relevance to the research problem, thereby refining the problem statement (Ridley, 2012). Conducting a literature review requires strategic keyword searches, the use of boolean operators to narrow down results, and leveraging references from key articles to build a robust and relevant body of literature (Fink, 2019). The stages of a literature review are problem formulation, literature search, evaluation, and analysis designed to create a logical, unbiased, and comprehensive overview that supports the research's development and ensures its relevance within the broader academic context (Creswell, 2014).

The third chapter, methodology provides a detailed blueprint of the study, including the subjects involved and the procedures followed, which enables replication by other researchers (Kallet, 2004). This section must be thorough and clear, covering statistical methods and definitions where necessary (Peat, 2001). For complex studies, the use of subsection headings can help organize the content, including frameworks, algorithms, and study group demographics (Albert & Tullis, 2013). It is crucial to ensure consistency in numerical data across sections, and to clearly state any ethical approval obtained for the study (Smith, 2017). While routine procedures may not need extensive detail, any major or unique techniques should be fully explained, with proper attribution given to borrowed methods (Day & Gastel, 2012). A solid understanding and description of statistical tests further enhance the study's credibility and allow for rigorous evaluation (Altman, 1991).

Further, in computing research, includes Systems Analysis and System Design, which could be divided into two separate chapters. Systems Analysis involves specifying what the system should do, while System Design focuses on how to achieve these requirements through appropriate architecture and technology choices (Sommerville, 2011). Depending on the study's complexity, these aspects may be divided into separate chapters to allow for thorough examination and discussion. The methodology not only serves as a guide for replicating the study but also ensures transparency in the research process, facilitating a better evaluation of the results and conclusions (Silverman, 2013). By providing a clear and detailed methodology, the research is framed within a context that can be critically assessed and built upon by future studies (Yin, 2018).

The next chapter, results provides a comprehensive account of the findings obtained from the study, encompassing all relevant data generated during the research process (APA, 2020). This section often includes the outcomes of Implementation and Testing, particularly in studies involving software development or engineering disciplines (Sommerville, 2011). Detailed descriptions of the hardware platform used, the choice of programming language, and the specific coding techniques employed are essential components that help contextualize the results and allow for reproducibility (Pressman, 2014). Additionally, this section should cover the testing procedures, including the test data used and the criteria for evaluating performance, as well as sample outputs that illustrate the

functionality and effectiveness of the developed system or solution (Myers & Well, 2013). By thoroughly documenting these elements, the Results section not only presents the study's findings but also provides the necessary context for understanding how these results were achieved, thereby contributing to the overall validity and reliability of the research (Mertler & Reinhart, 2017).

The discussion section of a research paper is pivotal as it provides a comprehensive summary of the results, interpreting them in the context of the research objectives and existing literature (Booth et al., 2016). This section explores the relationships between the findings, highlighting any patterns, correlations, or exceptions that emerged during the study. It is essential to compare these results with previous work to identify consistencies or discrepancies, thereby situating the current study within the broader academic discourse (Ridley, 2012). The discussion also delves into the theoretical or practical implications of the findings, explaining how they contribute to existing knowledge or practice and addressing the study's achievements and constraints (Creswell, 2014). Additionally, this section often includes a statement of the conclusions drawn from the research, emphasizing the significance of the results and how they advance understanding in the field. Finally, the Discussion typically outlines suggestions for further research, identifying areas where additional investigation could provide more insight or address unresolved issues (Yin, 2018). By thoroughly addressing these aspects, the Discussion not only interprets the results but also reinforces the study's contribution to the field and provides a roadmap for future research.

Finally, is a list of references and appendices which should be put at the end of the document. A recognized and consistent referencing system is vital for maintaining academic integrity and ensuring the clarity and reliability of a research report. It is essential to use a standardized referencing style, such as the APA (American Psychological Association) format, which is widely recognized in academic writing for its clarity and consistency (APA, 2020). All references, including those to web links, should be consolidated at the end of the report rather than distributed throughout the chapters. This approach not only maintains the flow of the main content but also ensures that the references are easy to locate and review (Perrin, 2015). Proper referencing is crucial as it acknowledges the original authors and helps avoid plagiarism, thereby enhancing the credibility and reliability of the research (Neville, 2016).

The appendices in a research report serve as supplementary sections that provide additional information, which supports the main text but is too detailed to include within the primary chapters. Most research projects include an appendix dedicated to the User Manual, which is essential if the research project involves the development of a system or software. The User Manual provides detailed instructions and technical documentation that guide end-users in operating the system effectively. This appendix should include step-by-step procedures, troubleshooting tips, and explanations of the system's functionalities (Carroll, 2014). A well-constructed User Manual not only improves user experience but also ensures that the system can be used as intended without requiring direct support from the developer. This is particularly important in research projects where the usability of the system is a critical factor in its evaluation and success (Nielsen, 2012). The other appendix includes sample programs, circuit diagrams, tables of data, and any other technical materials that are relevant to the research. This section is especially important for projects that involve coding or the development of hardware, as it provides concrete examples of the work conducted. Submitting the working systems along with the source code electronically ensures that the research is transparent and that other researchers can replicate the study if needed (Pressman, 2014). Including these materials in the appendix rather than the main body of the report helps maintain the focus on the research findings while still providing all necessary technical details for those who require them. This practice not only supports the integrity of the research but also aligns with best practices in documenting and sharing technical work (Glass, 2002).

5. Conceptualized Computing Projects Framework for Undergraduate Research

The conceptualized framework for guiding research process in computing projects begins with defining the research problem, which involves identifying a specific issue or gap that the project aims to address. This is followed by reviewing relevant concepts, theories, and existing systems to establish a strong theoretical foundation and context for the research. Based on these insights, the researcher formulates clear objectives and research questions to guide the study. The next step is system analysis and design, where tools like Entity-Relationship Diagrams (ERD), flowcharts, and use case diagrams are employed to model the system's architecture. A list of development tools is also prepared to outline the technologies and resources needed. During system development, the focus shifts to creating the interface, database, and coding the functionalities of the system. Once developed, the system undergoes rigorous testing to ensure it meets all requirements and functions correctly. The final phase involves presenting the project findings and compiling the entire process into a comprehensive report, effectively communicating the research outcomes.

In the framework, the system development, system testing, and presentation and report writing phases are interconnected through a feedback loop, represented by a double-sided arrow. This feedback mechanism ensures continuous improvement and refinement of the system as it progresses through these stages. During system development, as the interface, database, and coding are being constructed, ongoing testing is crucial to identify and rectify any issues or inefficiencies in real-time. The results from system testing provide essential feedback to the development team, allowing them to make necessary adjustments or enhancements to the system. Once the system is finalized and tested, the findings are presented and documented in the report writing phase. This phase also benefits from the feedback loop, as the insights and evaluations from the presentation stage can highlight areas for further refinement in both the system and the report. This iterative process ensures that the final output is not only technically sound but also thoroughly tested, well-documented, and effectively communicated.

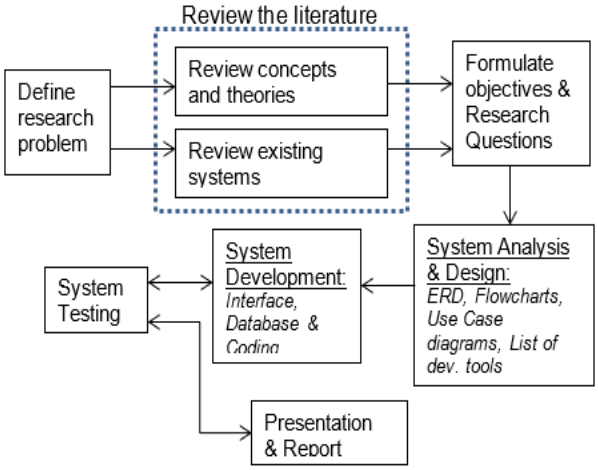

Figure 1: Computing Projects Framework for Undergraduate Research

6. Typical Project Evaluation Criteria

Computing project evaluation in the sampled university is done in two phases. Phase one is evaluation of the developed application done as continuous assessment and a presentation at the end of the semester. A tool is used for end of semester assessment while a typical evaluation criterion is considered to evaluate the presented documentation.

Assessing the developed application requires a comprehensive evaluation of various critical components that collectively determine the quality and effectiveness of the final product. The process begins by evaluating the relevance, originality, and uniqueness of the project title, which is more than just a name—it encapsulates the project's purpose and direction. A well-chosen title reflects the innovative aspects of the project and sets expectations for what the software aims to achieve (Hartley, 2014). The selection of development tools is another critical factor; these tools must align with the project’s objectives, ensuring that the implementation is both efficient and robust. The effectiveness of these tools directly influences the software's performance, scalability, and maintainability, all of which are essential for the project's success (Pressman, 2014).

Database design is a cornerstone of software development, and its evaluation focuses on the correctness of the Entity-Relationship Diagram (ERD) and the application of normalization

principles. A well-structured ERD ensures that all entities and relationships within the database are accurately represented, promoting data integrity and reducing redundancy. Normalization, meanwhile, is crucial for organizing the database into efficient structures, minimizing redundancy, and preventing update anomalies (Elmasri & Navathe, 2015). The ability to manipulate the master file—adding, updating, validating, and searching records—forms the backbone of data management within the software. This functionality must be reliable and user-friendly, as it ensures that data remains accurate and accessible throughout the software's lifecycle (Connolly & Begg, 2015).

The evaluation also extends to the software's transactional processes, which involve correctly retrieving values from the master file and implementing user-friendly features like search functions and dropdown lists. These processes must be smooth and error-free, as any issues can significantly impact the user experience and the software's overall reliability (Sommerville, 2016). Accurate calculations, whether involving summation, mean, or other statistical measures, are critical for the software's operational integrity. These calculations must be performed correctly to ensure that the software produces reliable and valid outputs (Ghezzi, Jazayeri, & Mandrioli, 2012).

Report generation capabilities are another vital aspect of software evaluation. The ability to generate general, summary, and parameterized reports with a well-organized layout is crucial for meeting the user's needs and enhancing the software's usability. The design and functionality of these reports must be evaluated based on their clarity, relevance, and how well they present the software's outputs to the end-user (Laudon & Laudon, 2018). Finally, the overall quality of the project is assessed through its coordination, ease of use, user-friendliness, and the absence of bugs. A well-coordinated, user-friendly, and bug-free project is indicative of a high standard of software development, reflecting the developer's commitment to delivering a reliable, efficient, and effective product (Schach, 2011). This thorough evaluation process ensures that all aspects of the software development project are meticulously examined, leading to a final product that meets both academic standards and practical expectations.

In assessing presented reports, a typical evaluation criterion begins with a thorough examination of the alignment between the title and the content of the paper, as well as the clarity and completeness of the abstract. The title is the first element that the reader encounters and should succinctly reflect the core focus of the research. If the title is misleading or too vague, it can set incorrect expectations, thereby diminishing the impact of the research (Hartley, 2014). The abstract, on the other hand, serves as a summary of the entire work, offering a snapshot that should accurately represent the key findings and methodologies. A well-crafted abstract allows readers to grasp the essence of the research without needing to read the full paper, which is particularly important in academic settings where readers often scan multiple abstracts to decide which papers to read in full (Swales & Feak, 2012). The introduction also plays a crucial role in setting the stage by clearly identifying the research problem and providing a brief yet comprehensive overview of the thesis. A strong introduction not only frames the research question but also outlines the structure of the paper, helping the reader to follow the argumentation and logic of the work (Creswell & Creswell, 2017).

Further evaluation criteria focus on the clarity and consistency of the terminology used throughout the paper. Clear definitions and consistent use of terms are essential for maintaining the readability and coherence of academic work. Authors must ensure that all key terms are well-defined and used consistently throughout the paper, adhering to the relevant scientific conventions (Day & Gastel, 2012). This consistency is vital in making the research accessible to its intended audience, particularly in interdisciplinary studies where terms may have different meanings across fields. The methodology section, in particular, is scrutinized for clarity and detail, as it is the foundation upon which the research's credibility is built. The methods must be described in enough detail to allow other researchers to replicate the study, which is a cornerstone of scientific research (Bryman, 2016). Any ambiguity or lack of detail

in this section can lead to misunderstandings or misapplications of the research methods, potentially undermining the study's validity (Silverman, 2020).

The evaluation of the research continues with a focus on the relevance and correctness of the results presented. Evaluators examine whether the analysis is conducted properly, and whether the techniques used are appropriate for addressing the research question (Flick, 2018). The results should be presented in a manner that is clear and logical, with tables and figures used to complement and clarify the text rather than confuse or contradict it (Miles, Huberman, & Saldaña, 2014). The objectivity of the results is also critical, as any bias in data presentation can compromise the scientific integrity of the research. The conclusions drawn from the study are then assessed for their reasonableness and scientific validity, ensuring that they are supported by the data and analysis presented (Maxwell, 2013). A well-written summary or conclusion section is essential for synthesizing the research findings and emphasizing their significance, thereby leaving a lasting impression on the reader.

Finally, the evaluation includes a meticulous review of the references and citations used in the research. Proper referencing is not only a matter of academic integrity but also a way to acknowledge the contributions of previous scholars to the current research (Neville, 2016). The references must be syntactically correct and there must be consistency between the sources cited in the text and those listed in the references section. Any discrepancies, such as sources cited but not referenced or vice versa, can undermine the credibility of the research (Perrin, 2015). Additionally, the placement and correctness of citations are evaluated to ensure they are logically integrated into the text and support the arguments made. Comprehensive coverage of relevant literature is also a critical factor in this evaluation, as it demonstrates the thoroughness of the research and its grounding in the existing body of knowledge (Machi & McEvoy, 2016). By adhering to these evaluation criteria, researchers can ensure that their work is well-structured, scientifically sound, and contributes meaningfully to their field.

7. Conclusion

In conclusion, the comprehensive guidelines and evaluation criteria outlined for computing research projects underscore the importance of meticulous planning, clear articulation, and rigorous assessment in the academic process. The integration of theoretical foundations with practical application is essential for bridging the gap between academic learning and real-world challenges, as demonstrated through the various stages of project development—from problem definition to final presentation. By adhering to these structured guidelines, students are not only equipped to produce high-quality, innovative software solutions but also to effectively communicate their findings in a well-organized and academically rigorous manner. The roles of the researcher, supervisor, and evaluator are pivotal in ensuring the success of these projects, fostering a collaborative environment that enhances the learning experience and contributes to the advancement of the computing field. Ultimately, this approach aims to produce graduates who are not only proficient in technical skills but also capable of contributing valuable insights and solutions to the broader technological landscape.

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