

Implementation of the Fluctuation Method in a Multi-user Web-based Student Cash Flow Application (Case Study: TK Amarta Semarang)

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ABSTRACT

Purpose of the study: This study aims to design and implement a web-based, multiuser student cash flow application at TK Amarta Semarang that applies the Fluctuation Method to record and manage student cash transactions accurately, replacing the previously manual recording process.

Methodology: This study used the Prototype development method, modeled with Unified Modeling Language (UML) diagrams (use case, activity, sequence, and class diagrams). The application was built using PHP, a MySQL database, and XAMPP web server, with Sublime Text as the code editor. Data were collected through observation and interviews, and the system was evaluated using Black Box Testing and White Box Testing (cyclomatic complexity).

Main Findings: The developed application successfully implements the Fluctuation Method within a multiuser web-based system accessible to the treasurer, teacher, and parents. Black Box Testing showed that all six tested menu functions produced the expected results, while White Box Testing on the cash income module yielded a cyclomatic complexity of $V(G) = 2$, indicating two independent, low-complexity execution paths and confirming the system's functional accuracy and structural reliability.

Novelty/Originality of this study: This study is novel in combining the Fluctuation Method with a multiuser, role-based web architecture specifically designed for an early childhood education institution, a combination not previously documented in prior literature. It benefits readers by offering a verified, low-complexity reference model for schools seeking to replace manual, error-prone cash recording with a transparent, testable digital system.

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1. INTRODUCTION

The development of information technology has encouraged various institutions, including educational institutions, to adopt digital systems to support administrative work efficiency [1]. The use of computer-based systems enables data processing to be carried out more quickly, accurately, and with lower risks compared to manual record-keeping [2], [3]. One area of administration that has also benefited from technological advancements is financial management, particularly cash flow management within institutions and educational organizations [4]. In early childhood education institutions, managing students' cash funds is a routine activity

that requires a transparent and accountable recording system for treasurers, teachers, and students' parents or guardians. Therefore, the implementation of a web-based information system is a relevant solution to support the management of student cash flow in a more modern, efficient, and integrated manner.

TK Amarta, located on Jalan Jodipati Barat, Semarang City, is one of the kindergartens that implements a student cash program as part of early financial management education. Currently, the student cash deposit process still involves homeroom teachers who receive weekly payments and subsequently submit them to the school treasurer for recording in the cash book [5]. The recording and storage of data, which are carried out manually using books and calculators, are vulnerable to the risks of lost records and damage caused by water or fire. In addition, the manual recapitulation process requires considerable time and may lead to calculation errors that affect the accuracy of student cash financial reports. These problems become increasingly complex because student cash management involves several parties simultaneously, namely the treasurer, teachers, and students' parents or guardians. Therefore, a system capable of accommodating multiple users simultaneously is required.

Several previous studies have developed web-based petty cash accounting information systems in various types of organizations. Fitriani et al. (2026) [6] designed a web-based petty cash accounting information system at PT. Jasa Marga Jalan Layang Cikampek using the CodeIgniter framework and Unified Modeling Language (UML). However, the system was implemented in a toll road service company and employed a general descriptive recording method rather than the fluctuating fund method [7]. Putri et al. (2023) [8] developed a web-based petty cash data management system at PT. Prima Karunia Kreasi that could be accessed simultaneously by multiple employees. However, the study did not implement the fluctuating fund method and was conducted in a construction company rather than an educational institution. Hernawati et al. (2024) [9] designed a web-based petty cash accounting information system using the Agile Development method at PT XYZ, a company operating in the financial services sector. Nevertheless, the research remained focused on a commercial organization and did not address the school context. Hakim et al. developed a web-based school cash receipt and disbursement application integrated with a WhatsApp Gateway at SMK Nurut Taqwa Songgon using the Rapid Application Development (RAD) method [10]. However, the system did not implement the fluctuating fund method for recording cash flows.

Based on the aforementioned previous studies, it can be observed that the application of the fluctuating fund method in web-based petty cash systems has generally been implemented in companies or government institutions rather than in early childhood education institutions. Meanwhile, studies on web-based cash management systems in schools have predominantly employed system development methods such as RAD or Agile without adopting the fluctuating fund method for financial recording [11]. No study has specifically been identified that implements the fluctuating fund method in a student cash application using a multiuser concept that integrates the roles of treasurers, teachers, and students' parents or guardians. This research gap indicates that the combination of the fluctuating fund method, multiuser concept, and an early childhood education institution as the research setting remains an area that has received limited attention in previous studies. Therefore, this study seeks to address this gap by developing a web-based student cash application that specifically implements the fluctuating fund method in the case of TK Amarta Semarang.

The implementation of a web-based information system for managing student cash at TK Amarta is important considering the risks associated with manual recording, such as data loss and calculation errors [12]. A computerized system can improve the transparency and accountability of student cash financial reports, enabling accurate information to be provided to all relevant parties, particularly students' parents or guardians. The multiuser concept is also essential in this application because it allows treasurers, teachers, and parents or guardians to access information according to their respective needs and authorities [13]. Furthermore, the application of the fluctuating fund method is considered appropriate because the amount of student cash may change according to the operational needs of the school, making this method more flexible than the imprest fund method. The urgency of this research is further emphasized by the limited number of early childhood education institutions that have computerized, transparent, and operationally responsive student cash management systems.

Based on the problems and research gaps described above, this study aims to design and implement a web-based student cash flow application using the fluctuating fund method. This study also aims to develop a system capable of accommodating multiple users, namely treasurers, teachers, and students' parents or guardians, with different access rights according to their respective roles. In addition, this study aims to produce an application that facilitates the recording, management, and reporting of student cash receipts and expenditures more quickly and accurately. The study also aims to evaluate the functionality of the developed application through black-box and white-box testing to ensure that all features operate as expected [14]. Ultimately, this research is expected to provide a solution for TK Amarta Semarang in managing student cash in a more transparent, secure, and integrated manner through a web-based system.

The novelty of this study lies in the application of the fluctuating fund method combined with a multiuser concept in a student cash application, a combination that has rarely been found in previous studies. Unlike previous research, which has generally applied the fluctuating fund method in corporate contexts, this study specifically implements the method in an early childhood education institution, namely TK Amarta

Semarang. This study also introduces clearly defined access rights for treasurers, teachers, and students' parents or guardians, allowing each user to obtain student cash information according to their respective needs and authorities. Furthermore, the developed application is designed using the Prototype system development method and modeled using the Unified Modeling Language (UML), followed by black-box and white-box testing to ensure system quality [15]. Thus, this study contributes a novel model of a web-based student cash application specifically designed for the kindergarten education level by simultaneously incorporating the fluctuating fund method and a multiuser concept.

2. RESEARCH METHOD

2.1 Research Design

This study employs an applied research approach with a descriptive qualitative method oriented toward software development research. This design was chosen because the study aims to produce a tangible product, namely a web-based student cash flow application that can be directly implemented to solve the problem of student cash management at TK Amarta Semarang. The system development process in this study uses the Prototype method, which was selected because it can bridge the gap between user requirements where users do not yet fully understand technical aspects and the developer's need to formulate system specifications gradually. Through this approach, the application is built iteratively, starting from requirements gathering, initial model creation, to testing and refinement based on user feedback, in this case the school treasurer acting as the system's main admin.

2.2 Research Subjects and Objects

The subjects of this study are the parties directly involved in managing student cash at TK Amarta Semarang, namely the school treasurer responsible for student cash finances, the teacher who also helps manage student data and cash transactions, and the parents/guardians who receive the cash report information. The object of this study is a web-based, multiuser student cash flow application that implements the Fluctuation Method for recording student cash income and expenditure [16]. This study does not use population and sample in the statistical sense; instead, it uses a purposively selected key informant, namely the treasurer of TK Amarta, who directly handles the daily recording of student cash and is therefore considered to have the most comprehensive understanding of the current business process.

2.3 Data Sources and Data Collection Techniques

The data sources in this study consist of primary and secondary data. Primary data were obtained directly from observation and interviews with the school treasurer of TK Amarta regarding the current process of recording and calculating student cash [17]. Secondary data were obtained from a literature study, including books, scientific journals, and online references relevant to information systems, the Fluctuation Method, and web-based application development. Data collection was carried out using three techniques:

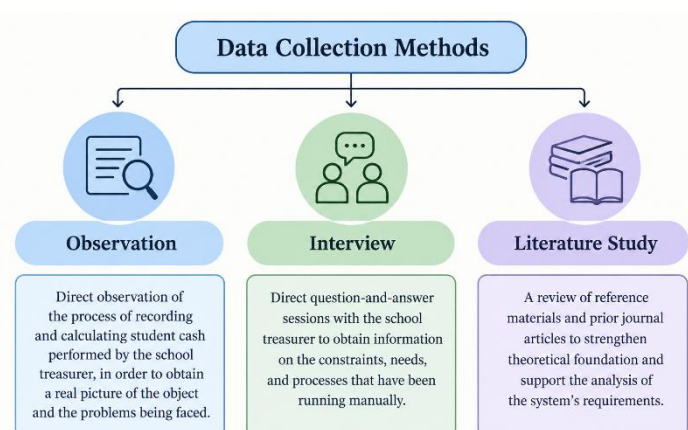


Figure 1. Data Collection Methods

2.4 Research Instruments

The research instruments consisted of non-technical and technical instruments used throughout the system development process. Non-technical instruments included observation and interview guidelines, which were used to identify existing problems and explore functional requirements from the users' perspective. Technical instruments included hardware, software, programming languages, database technologies, and

modeling tools used to design, develop, and test the application [18]. These instruments supported the implementation of the web-based student cash flow application from the requirements analysis stage through system testing. The technical instruments and their specifications or functions are presented in Table 1.

Table 1. Research Instruments (Hardware and Software Requirements)

No.	Category	Instrument	Specification / Function
1	Hardware	Processor	Intel Core i3, 2.0 GHz
2	Hardware	RAM	4 GB
3	Hardware	Hard Disk	500 GB
4	Software	Operating System	Microsoft Windows 10
5	Software	XAMPP	Local web server (Apache and MySQL) used to run the application
6	Software	Sublime Text	Code editor used to write PHP program code
7	Software	Web Browser	Used to run and test the application's interface
8	Programming Language	PHP	The main programming language used to develop the application
9	Database	MySQL	Used to manage the student cash application database
10	Modeling Tool	UML (Unified Modeling Language)	Used to design the use case, activity, sequence, and class diagrams

Table 1 summarizes the technical instruments required to support the development of the application. Hardware resources provided the computing environment, while the operating system, XAMPP, Sublime Text, and web browser supported the development and testing activities. PHP and MySQL were used as the primary technologies for application development and database management, respectively. UML was used to represent the system structure and processes during the design stage. The combination of these instruments provided the technical environment required to develop and test the web-based student cash flow application.

2.5 Data Analysis Technique

Data obtained from observation and interviews were analyzed descriptively and qualitatively to formulate the system's functional requirements, including user requirements (treasurer, teacher, parents/guardians), data requirements (student data, income data, expenditure data), and business process requirements for implementing the Fluctuation Method. The results of this requirements analysis were then modeled using UML diagrams, particularly the use case diagram, to describe the interaction between actors and the system. At the testing stage, data analysis was carried out using two techniques:

- a) Black Box Testing : Assesses the correspondence between the system's input and output on each menu, without examining the program code structure, to ensure each function produces the expected output.
- b) White Box Testing : Assesses the program's internal logical structure through basis path testing, by calculating the cyclomatic complexity to determine the number of independent paths within a procedure, ensuring that all execution paths have been tested.

2.6 Research Procedure

The research procedure followed the Prototype method and consisted of three main stages: communication, quick planning and modeling, and evaluation and testing. Each stage was conducted to progressively develop the web-based student cash flow application according to the identified user requirements [19]. The process began with requirements gathering, followed by system modeling and prototype development, and continued with evaluation and testing. Feedback obtained during the evaluation stage was used to identify shortcomings and additional requirements for subsequent improvements. The activities and outputs of each stage are presented in Table 2.

Table 2. Research Procedure Stages Based on the Prototype Method

No.	Stage	Stage Name	Activity	Output
1	Communication	Communication	Observation and interviews with the	List of user requirements

			school treasurer of TK Amarta to gather system requirements.	and problems encountered.
2	Quick Plan and Modeling	Quick Plan and Modeling	System design using UML (use case, activity, sequence, and class diagrams), followed by building an application prototype using PHP and MySQL.	System design and application prototype for student cash management.
3	Trial Evaluation	/ Trial Evaluation	/ The prototype is submitted to TK Amarta for evaluation; Black Box and White Box testing are conducted.	Finalized application that has been tested and meets user requirements.

Table 2 shows the sequential development process based on the Prototype method. The communication stage established the initial requirements by identifying problems and user needs, while the quick planning and modeling stage translated these requirements into system designs and an application prototype. Evaluation and testing were then conducted to verify the functionality and suitability of the developed application [12]. If shortcomings or additional requirements were identified during evaluation, the development process returned to the communication stage for further refinement. This iterative process continued until the application was considered suitable for full implementation at TK Amarta Semarang.

3. RESULTS AND DISCUSSION

This section presents the results of the development and testing of the web-based, multiuser student cash flow application for TK Amarta Semarang, followed by a comprehensive discussion linking these results to the research objectives and to relevant prior studies.

3.1. System Implementation Results

The developed system consists of seven integrated menus that are accessible according to three user roles: treasurer, teacher, and parent/guardian. These menus include Login, Dashboard, User Management, Student Data, Cash Income, Cash Expenditure, and Report, as summarized in Table 3. The Login menu authenticates users through a username and password before providing access to the role-specific Dashboard. User Management and Student Data are available to the treasurer and teacher to manage user accounts and student records used as reference data for cash transactions [12]. The Cash Income menu applies the Fluctuation Method by recording each student's weekly deposit against the required nominal and automatically carrying forward any shortfall to the following week rather than assuming a fixed periodic amount. Cash Expenditure and Report complete the transaction management process by enabling the treasurer to record outgoing funds and providing parents/guardians with read-only access to income and expenditure recapitulations. This structure supports more systematic cash management and reduces the need for manual verbal or paper-based reporting previously used at TK Amarta.

Table 3. Menu Role Mapping of the Developed System

No.	Menu	Treasurer	Teacher	Parent/Guardian
1	Login	✓	✓	✓
2	Dashboard	✓	✓	✓
3	User Management	✓	–	–
4	Student Data	✓	✓	–
5	Cash Income (Fluctuation)	✓	✓	–
6	Cash Expenditure	✓	–	–
7	Report	✓	✓	✓ (View Only)

Table 3 shows that system access is differentiated according to the responsibilities of each user role. The treasurer has the broadest access because this role is responsible for managing user accounts, student data, cash income, cash expenditure, and reports [20]. Teachers can access student data, cash income, and reports to support their administrative activities, while parents/guardians are provided with dashboard and report access for monitoring purposes. Parent/guardian access to the Report menu is restricted to viewing information without modification privileges. This role-based access structure helps ensure that each user can access the functions relevant to their responsibilities while limiting unauthorized changes to financial data.

3.2 System Testing Results

System testing was conducted using black-box and white-box testing techniques to evaluate the developed system from functional and structural perspectives, respectively, following the testing approaches described in. Black-box testing focused on verifying whether the system produced the expected outputs based on predefined user actions without examining the internal program structure. Six main scenarios were tested, covering student data, user management, authentication, cash income, cash expenditure, and reporting functions. All tested scenarios produced successful results and were consistent with the expected outputs. The black-box testing results are presented in Table 4.

Table 4. Black Box Testing Results

No.	Test Scenario	Expected Result	Test Result
1	Access Student menu	Displays Student Data page	Successful / OK
2	Access User menu	Displays User Data page	Successful / OK
3	Enter username and password, then click Login	Displays Dashboard page	Successful / OK
4	Access Cash Income menu	Displays all students' monthly cash data	Successful / OK
5	Access Cash Expenditure menu	Displays cash expenditure data	Successful / OK
6	Access Report menu	Displays income–expenditure report	Successful / OK

Table 4 shows that all six tested scenarios achieved a Successful / OK result. The tested functions, including authentication, student and user data access, cash income, cash expenditure, and reporting, produced outputs consistent with the predefined expectations. These results indicate that the main system functions operated correctly based on the tested user interactions [21], [22]. The successful black-box testing results provide functional evidence that the developed system can support the main student cash management processes [23]. All six scenarios produced outputs consistent with their expected results, indicating that the system's core functions perform as intended. States that basis path testing using cyclomatic complexity provides a reliable indicator of a program's structural quality prior to deployment; consistent with this, the White Box Testing applied to the Cash Income flowgraph produced a cyclomatic complexity of $V(G) = 2$, obtained through both the region-count method ($V(G) = 2$ regions) and the edge–node formula ($V(G) = E - N + 2 = 8 - 8 + 2 = 2$), yielding two independent execution paths (1-2-3-4-5-6-8 and 1-2-3-4-5-6-7-5-6-8). This low complexity value indicates that the fluctuation-based transaction logic is structurally simple, testable, and maintainable.

The results obtained in this study directly address the objectives set at the outset of the research. The implementation of the Cash Income menu confirms that the Fluctuation Method can be operationalized in a web-based system by recording actual weekly deposits and automatically carrying forward shortfalls, replacing the manual, calculator-based recording process previously used by the TK Amarta treasurer. The role-based access implemented through the Dashboard and User menus confirms the achievement of the multiuser objective, ensuring that the treasurer, teacher, and parents each interact with the system according to their respective responsibilities [24], [25]. The fully successful Black Box Testing results and the low cyclomatic complexity obtained from White Box Testing confirm that the system's functionality has been verified both externally and internally. Taken together, these findings indicate that all research objectives concerning design, implementation, multiuser accommodation, and functional verification have been fully met.

These findings are also supported by, and consistent with, results reported in prior testing-focused studies. Found that Black Box Testing is an effective method for validating input output correctness in web-based information systems without requiring inspection of the underlying code, a conclusion mirrored by the fully successful test scenarios obtained in this study. Similarly demonstrated that a low cyclomatic complexity value obtained through basis path testing reflects a well-structured and reliable program module, which aligns closely with the $V(G) = 2$ result obtained for the Cash Income process in this study [26]. This convergence

indicates that the testing outcomes of the TK Amarta application are not an isolated finding but are corroborated by methodologically comparable research on software quality assurance. Such alignment strengthens the internal validity of the conclusion that the developed system is both functionally correct and structurally sound.

With respect to each key variable examined in this study, the Fluctuation Method variable proved appropriate for student cash management, where weekly deposit amounts vary according to each family's payment capacity rather than following a fixed nominal as in the imprest fund approach. The multiuser variable proved essential in a school environment where financial responsibility is inherently distributed among the treasurer, teacher, and parents, and the differentiated access implemented in this study ensured transparency without compromising administrative control [27]. The Prototype development method variable enabled requirements to be refined iteratively based on direct feedback from the treasurer, who had limited technical background, thereby reducing the risk of specification mismatch. The testing variable, comprising Black Box and White Box techniques, provided complementary evidence of correctness from both a functional and a structural standpoint. Collectively, these four variables interacted to produce a system that is not only functionally complete but also verifiably reliable.

When compared with prior research, this study both confirms and extends existing findings in the field. Fitriani et al. [1] and Hernawati et al. [3] each developed web-based petty cash accounting systems for a toll-road service company and a financial services company respectively, yet neither applied the Fluctuation Method nor incorporated a multiuser structure extending beyond internal staff. Putri et al. [2] implemented multi-employee web access for a petty cash system at a construction contractor, supporting this study's finding that multiuser access improves usability, although that system likewise did not adopt the Fluctuation Method. Hakim et al. [4], working within a school context, developed a web- and WhatsApp Gateway-based school cash application using the RAD method, paralleling the institutional setting of this study but without a fluctuation-based calculation mechanism. These comparisons indicate that while individual elements of this study's approach have precedent in the literature, no prior work has combined the Fluctuation Method with multiuser, role-based access within an early childhood education setting.

This confirms the novelty proposed in the introduction of this study, namely the integration of the Fluctuation Method with a multiuser architecture specifically designed for a kindergarten institution, a combination not previously documented in the reviewed literature [28]. The successful Black Box and White Box testing results provide empirical evidence that this combination is not merely conceptually feasible but technically implementable and reliable in practice. This finding closes the research gap identified earlier, in which fluctuation-based systems had largely been confined to corporate and governmental contexts, while school-based cash applications had relied on methods other than fluctuation. The novelty therefore lies not in any single component of the system, but in the successful convergence of method, user structure, and institutional context within one verified application. This positions the present study as a reference point for future research seeking to apply similar financial recording methods within early childhood education administration.

The findings of this study carry both practical implications and notable limitations. Practically, the resulting application offers other kindergartens or early childhood institutions a low-complexity, testable model for replacing manual cash recording with a transparent, role-based web system, potentially reducing administrative burden and the risk of data loss from paper-based archives [29]. At the institutional level, the implication for TK Amarta specifically is improved transparency for parents and reduced calculation error for the treasurer [30]. However, this study is limited by its single-case design, relying on one key informant from a single institution, which restricts the generalizability of the findings to schools with substantially different organizational structures or transaction volumes. Furthermore, testing was limited to Black Box and White Box techniques applied primarily to the Cash Income module, without broader usability or security testing across all system modules, leaving room for more comprehensive evaluation in future research.

4. CONCLUSION

This study has successfully designed and implemented a web-based, multiuser student cash flow application for TK Amarta Semarang using the Fluctuation Method, in accordance with the objectives outlined in the Introduction. The results confirm that the Fluctuation Method can be effectively operationalized within a web-based system, allowing weekly student cash deposits to be recorded according to actual amounts rather than a fixed nominal, with any shortfall automatically carried forward—thereby replacing the manual, calculator-based recording process that previously caused delays and calculation errors at TK Amarta. The multiuser architecture, with differentiated access for the treasurer, teacher, and parents/guardians, has also been successfully implemented and verified, enabling each user to interact with the system according to their respective role and responsibility, which directly addresses the complexity of involving multiple stakeholders in student cash management identified at the outset of this research. Furthermore, the system has been proven reliable through Black Box Testing, in which all tested scenarios produced the expected output, and through White Box Testing, which yielded a low cyclomatic complexity value ($V(G) = 2$) for the cash income module,

indicating that the transaction logic is structurally simple, testable, and maintainable. Taken together, these findings demonstrate strong compatibility between what was proposed in the Introduction and what was ultimately achieved in the Results and Discussion, confirming that the research gap concerning the combined application of the Fluctuation Method and multiuser access within an early childhood education setting has been successfully addressed.

Beyond its immediate contribution, this study opens several prospects for further research and development. Future studies could extend the current system by integrating automated notification features, such as SMS or WhatsApp Gateway reminders for parents regarding weekly payment deadlines or outstanding balances, building on approaches previously explored in school-based cash applications. The system could also be enhanced with more advanced financial reporting features, such as automated monthly and annual financial statements or data visualization dashboards, to further support the treasurer's decision-making and improve transparency for school management. In terms of testing, subsequent research is encouraged to broaden the scope of White Box Testing to cover all system modules rather than the cash income process alone, and to incorporate usability and security testing to provide a more comprehensive assessment of software quality. Finally, given that this study was limited to a single-case design at one kindergarten, future research could apply and validate this Fluctuation Method–multiuser model across multiple early childhood education institutions to strengthen the generalizability of the findings and to establish it as a broader reference architecture for student cash management systems in the education sector.

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