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Feature-Driven Development as a Strategy for Managing Requirements for LearnBIM Application

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ABSTRACT

In the dynamic landscape of ICT industry, requirements have become a persistent challenge which may incur costs, delayed timelines and changing requirements. In managing ambiguous requirements, agile software methodology able to address volatile requirements during the software development process. Existing technological initiatives such as mobile applications and recognition datasets are often constrained to prototypes and lack structured development methodologies. Therefore, this study presents the development of LearnBIM, a gamified mobile learning application designed to support Malaysia Sign Language (MSL) learning for both hearing and non-hearing users. LearnBIM has adopted Feature-Driven Development (FDD) as the selected agile software methodology by offering a structured yet iterative approach for systematically eliciting and translating user requirements into functional features. The development process also used FDD to integrate gamification elements such as quizzes, badges, and progress dashboards for enhancing usability. Findings indicate that applying FDD facilitated traceability, modularity, and user-centered design, resulting in a pedagogically grounded and accessible application.

1. INTRODUCTION

Software engineering methodologies play a critical role in ensuring that user requirements are effectively captured and translated into functional, user-centered systems. Traditional linear models, such as the Waterfall model, offer structure but lack flexibility for projects that require iterative refinement, while Agile methods support adaptability but may not provide sufficient feature-level granularity for complex educational applications (Ay, 2024). In software development, Feature-Driven Development (FDD) offers an alternative by emphasizing feature modeling, iterative development, and continuous user involvement. This structured yet flexible approach makes FDD particularly well-suited to the development of educational and assistive technologies that require modularity, scalability, and close alignment with user needs. This

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study highlight FDD adoption in implementing LearnBIM, a gamified mobile application designed to support the learning of Malaysian Sign Language (MSL). This study demonstrates how FDD can be systematically applied to elicit, refine, and implement user requirements within an inclusive educational context. By documenting the structured application of FDD in the design of LearnBIM, this study contributes to both software engineering practice and educational technology development. It provides insights into how a FDD approach can improve usability, inclusivity, and learner engagement through systematic requirement integration. This paper has 4 sections. Section 2 reviews relevant literature on this study. Section 3 outlines the methodology, detailing how FDD was applied throughout the development process. Section 4 presents the results and discusses the implications of applying FDD in this context. Finally, Section 5 concludes with contributions, limitations, and directions for future work.https://libraryguides.vu.edu.au/apa-referencing

2. LITERATURE REVIEW

This section highlights an overview of sign language and accessibility in the Malaysian context, existing studies on mobile learning for sign language, gamification, and learner engagement in digital language learning, and the importance of FDD as a software engineering methodology for assistive systems.

2.1 Overview of sign language and accessibility in the Malaysian context

Hearing loss remains a significant global health and social challenge, affecting more than 466 million people worldwide, with projections indicating this number could exceed 700 million by 2050 (Maru, 2021). For the Deaf and hard-of-hearing communities, sign language serves as a fundamental means of communication, cultural identity, and social participation. Despite its importance, sign language remains underutilized among hearing individuals, perpetuating communication barriers and contributing to the social exclusion of Deaf communities (Hafit et al., 2019). In Malaysia, these challenges are particularly pronounced. Malaysian Sign Language (Bahasa Isyarat Malaysia, or MSL) has limited visibility within mainstream education and public spaces, and opportunities for hearing individuals to learn MSL remain scarce (Alshoura, 2021; Razak & Senan, 2022). The emergence of mobile technologies and gamified learning platforms offers promising opportunities to bridge this communication divide. Mobile learning applications can provide accessible, self-directed, and interactive environments for learners (Lazaro & Duart,2023). Applications such as Lingvano and Pocket Sign have popularized sign language learning for American Sign Language (ASL) through interactive video-based lessons and gamified experiences. However, many of these tools rely heavily on static content, lack cultural and linguistic localization, and struggle to maintain long-term user engagement (Wang et al., 2023). More critically, they are often developed without systematic methodologies for eliciting and validating user requirements, resulting in applications that do not fully meet the needs of both hearing and non-hearing learners (Hashim et al., 2024).

2.2 Existing studies on mobile learning for sign language

Mobile learning or m-learning has matured from a collection of device-centred experiments into an established field with robust empirical support that mobile platforms can facilitate access, personalization, and learning across contexts (Parsons et al., 2023). The use of mobile platforms helps in terms of its portability, ubiquitous connectivity, and the ability to deliver contextual learning experiences. The use of mobile learning aligns well with language learning goals, where frequent exposure and spaced practice are pedagogically advantageous (Kuimova et al., 2018). Applied to sign language, mobile devices offer several affordances: video playback for visual demonstration, camera or mirror-mode features for practice and self-assessment, and asynchronous, just-in-time access for learners who may not have local instructors. Several MSL and sign language applications have used digital tools to present vocabulary, sign sequences, and

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interactive quizzes. However, most Malaysian prototypes, such as the Basics MSL app and early mobile projects, are still in the pilot phase

2.3 Gamification and learner engagement in digital language learning

This section elaborates on the gamification in improving learner engagement. The application of game design elements in non-game contexts has become a prominent design strategy for sustaining learner motivation and engagement in digital education. The empirical literature and systematic reviews show consistent evidence that gamification can increase engagement, persistence, and sometimes learning outcomes when design choices align with learning objectives (Jun & Lucas, 2024; Gejandran & Abdullah, 2024). For sign language learning, gamification can encourage repeated practice through streaks and progress, scaffold complexity such as tiered lessons and unlockable content, and offer low-stakes assessment, namely quizzes and badges. Commercial ASL apps such as Lingvano, Pocket Sign demonstrate market appetite for gamified approaches where these applications combine video lessons with practice tasks and reward structures to encourage daily use. However, evaluations of these applications in peer-reviewed literature are limited, and few address the needs of localized sign languages such as MSL.

2.4 The importance of FDD as a software engineering methodology for assistive systems

Choice of development methodology matters for educational systems where pedagogical correctness, accessibility, and maintainability are essential. Traditional model, known as Waterfall, provides traceability but is ill-suited to projects requiring frequent user feedback and iterative pedagogy tuning. In this case, agile methods emphasize iteration and stakeholder collaboration but sometimes under-specify feature-level deliverables in large or highly-modular systems (Mishra & Alzoubi, 2023). In contrast, Feature-Driven Development (FDD) is an agile-flavoured approach that foregrounds domain modeling, a hierarchically organized feature list, and short feature-centric iterations; it therefore provides both the flexibility of iterative development and the granularity needed to trace pedagogical requirements to implementation artifacts (Bambazek et.al, 2023).

Feature-Driven Development (FDD) offers a structured, feature-centric approach that supports incremental and user-oriented development, making it well-suited for mobile applications targeting assistive technologies such as sign language learning. Feature-Driven Development (FDD) consists of five core activities, such as developing an overall model, building a features list, planning by feature, designing by feature, and building by feature. Compared to more flexible Agile methods like Scrum, FDD may offer less adaptability in projects with evolving learning content or diverse user needs. Nonetheless, its methodological clarity and alignment with mobile-based, feature-driven learning modules present a promising yet underexplored avenue in sign language educational technology (Booton et al., 2023; David et al., 2024).

3. METHODOLOGY

This section elaborates on how LearnBIM is developed using the FDD model. It elaborates on the overall model of FDD, builds a feature list, plans by feature, designs by feature, and build by feature.

3.1 Research Design

This study employed Feature-Driven Development (FDD) as the primary software engineering methodology to design and develop LearnBIM, a gamified mobile application for learning Malaysian Sign Language (MSL). FDD was selected because it integrates the structured modeling of traditional approaches with the iterative refinement of agile methods, making it particularly appropriate to cater to changing requirements in user-centered design for assistive technologies. The methodological approach focused on

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systematically eliciting user requirements, translating them into functional features, and iteratively developing and validating the application with both hearing and non-hearing participants. Fig. 1 illustrates FDD process for developing LearnBIM application.

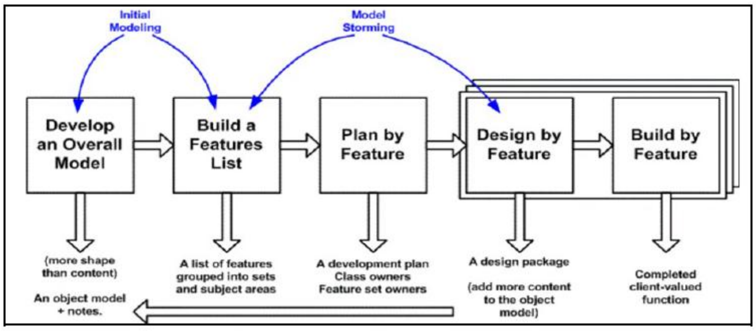

Fig. 1. Feature-Driven Development (FDD) model

3.1.1 Develop an Overall Model

During the first phase of the Feature-Driven Development model (FDD), known as Developing an Overall Model, the requirements for LearnBIM system have been gathered from the existing sign language mobile applications. These include analysing existing sign language applications to identify key features such as user interface design, gamification elements, and lesson progression. To further analyse unclear requirements for the LearnBIM system, related sign language mobile applications such as Lingvano, Pocket Sign, and ASL Bloom have been compared and studied to extract features, identify strengths, and identify the limitations of the system. These applications serve as a guide to gather requirements, as they provide valuable insights into user needs and help to improve the design and structure of LearnBIM system.

3.1.2 Build a Features List

The second phase, known as, Build a Features List, will identify and define LearnBIM system features based on the gathered requirements in the first phase. This phase involves building a detailed list of features, which acts as a guide for the development of the system. The requirement is divided into major feature sets, which are then further divided into specific feature sets. A possible feature list for the system is created based on the requirements that have been collected from the existing system. This phase listed all the possible requirements into major feature sets, such as “Account Management”, “Lesson Management”, “Gamification and Progress Tracking”, and “Notification Management. Each of these major feature sets is divided into more specific feature sets. As an example, the “Lesson Management” major feature set is divided into specific feature sets such as “User Lesson Interaction” and “Admin Lesson Content Management”. In addition, each feature set contains activities or individual features that help to enhance the user experience. This method of feature breakdown allows each requirement to be easier to handle and implement, ensuring that the system’s development stays focused on satisfying user needs. Hence, all identified and categorised features are documented in a features list, which serves as a detailed guide throughout the development process.

3.1.3 Plan by Feature

Plan by Feature, which is derived from the previously approved features list, consists of a detailed timeline for each feature as well as a schedule for the system’s major milestones. In the context of the LearnBIM system, the core features are prioritised, including learning components such as interactive

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learning modules and video tutorials, alongside gamification elements like leaderboards and quizzes. These features are arranged and developed based on their priority to the users and their functionalities. This approach ensures that the high-priority features are completed first, allowing the system's main functionality to be established earlier.

3.1.4 Design by Feature

The fourth phase, Design by Feature, focuses on creating detailed designs for each feature, providing a framework for the development process. In this phase, the list of selected features from the previous phase are scheduled for the development process to ensure each feature will be designed with clear specifications. In LearnBIM system, this involves designing core features such as learning modules and gamification elements like quizzes and leaderboards. The possible use case diagram and entity relationship diagram are illustrated based on the requirements gathered from the existing system to ensure better user experience and efficient system performance.

3.1.5 Build by Feature

This section describes the Build by Feature phase in the Feature-Driven Development Model. Build-by-Feature is the last phase of the Feature-Driven Development model (FDD). The main activity in this phase is the development and implementation of features based on the gathered requirements, designs, and plans from the previous phases. The implementation involves coding, testing, and integrating the features into LearnBIM system to ensure that the features work correctly and interact with other components. Next, Section 4 elaborates on the results and discussion for this paper.

4. RESULTS AND DISCUSSION

This section discusses elicited requirements and feature model, system modelling on use case and ERD Interpretations and Data Flow Diagram and User Interface.

4.1 Elicited requirements and feature model

The requirement elicitation process produced a structured set of user-centered functional and non-functional requirements, which were systematically organized into FDD feature groups. Three main categories of features were identified after requirements elicitation is done. It consists of User Management, Learning and Engagement, and Administrative Management. User Management features supported basic account operations, including account creation, updates, and deletion. Learning and Engagement features included browsing and searching for lessons, attempting quizzes, viewing progress, and receiving notifications. Administrative Management features covered content updates, deletion, and user performance analytics. By decomposing these requirements into discrete, independently deliverable features, FDD facilitated traceability between user needs and technical implementation. This feature-driven structure ensured that development proceeded incrementally, enabling early validation with users and reducing integration risks.

4.2 System modeling: Use Case and ERD interpretations

The use case diagram provided a clear visualization of the LearnBIM system's functional scope, depicting interactions between two key actors, which are User and Admin. User functionalities centered on learning and engagement, reflecting a learner-centric design that supports content exploration and progress tracking. Administrative functions, by contrast, focused on content maintenance and analytics, enabling educators or system administrators to ensure content quality and monitor learner performance. This dual-

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role design reinforces system sustainability while maintaining simplicity for end users. Fig. 2 depicts Use Case Diagram for LearnBIM application.

Fig. 2. Use Case Diagram for LearnBIM

Within the FDD framework, the Entity–Relationship Diagram (ERD) translated the feature list into structured data models. Entities such as User, Lesson, Quiz, Progress, and Notification were derived directly from elicited requirements. Fig. 3 reveals the Entity Relationship Diagram for LearnBIM. According to Fig. 3, the User entity supported authentication and profile management, while the Lesson and Quiz entities enabled linking learning content with assessments. A Progress entity tracked individual learner performance, and Notification entities supported engagement through updates and reminders. Administrative actions were modeled through relationships connecting Admin, Lesson, and User Analytics entities. By grounding the ERD in the feature model, the design maintained a clear trace from user requirements to database schema, consistent with FDD's emphasis on structured modeling.

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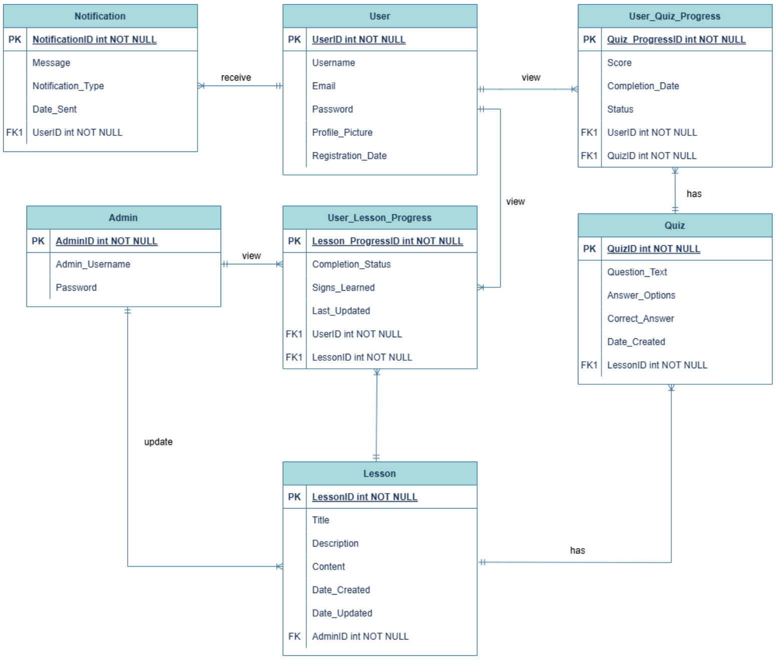

Fig. 3. Entity Relationship Diagram for LearnBIM

4.3 Data flow diagram and user interface

In clarifying requirements for LearnBIM, the FDD also plays its part in outlining how users and admins interact with the application. Therefore, the data flow diagram, as shown in Fig. 4, is finalized at the 'Plan by Feature' Stage in FDD.

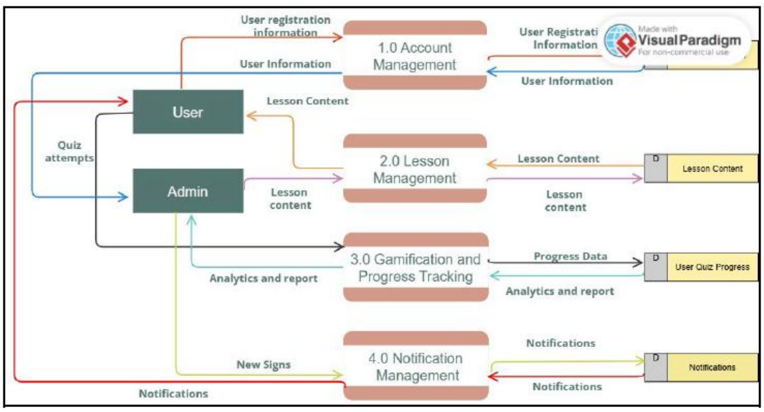

Fig. 4. Data Flow Diagram for LearnBIM

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Fig. 5 shows a sample of LearnBIM in assisting user for learning sign language using the application. These findings are consistent with prior studies demonstrating that gamification can enhance engagement, retention, and learner satisfaction when integrated meaningfully into mobile learning environments. Administrative users reported that content management features and analytics tools were straightforward, enabling them to update learning materials and monitor user progress with minimal technical training.

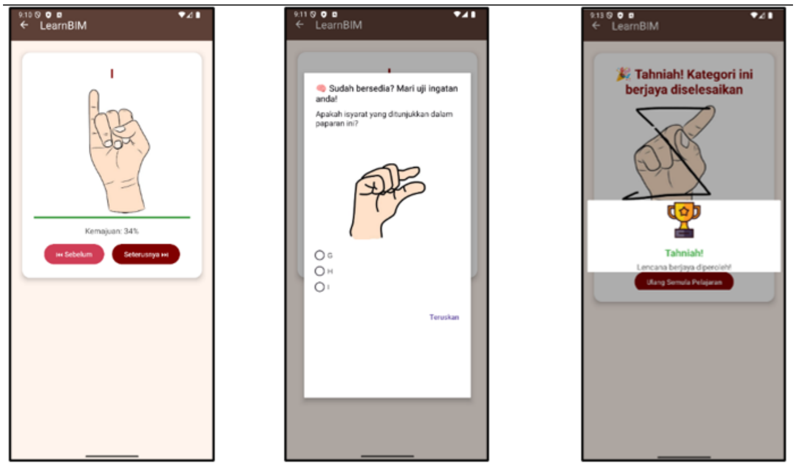

Fig. 5. Sample of LearnBIM in assisting users for learning sign language using the application

From a methodological perspective, applying FDD proved advantageous in several ways. First, the feature-oriented breakdown ensured that each user requirement was clearly defined, scoped, and linked to implementation, reducing ambiguity and supporting iterative refinement. Second, the incremental development and validation cycles allowed user feedback to be incorporated early, which improved usability and reduced costly post-development revisions. Finally, the structured modeling stages provided clear documentation, supporting scalability and future enhancement. Compared to many existing sign language learning applications that are developed using ad hoc methods or without explicit requirement modeling, LearnBIM's development illustrates how FDD can enhance both software quality and user experience in educational technology contexts, and it eases the developer to manage changing requirements.

5. CONCLUSION

In conclusion, the development of the LearnBIM application demonstrates the effectiveness of Feature Driven Development (FDD) in implementing a structured, user-centred sign language learning system. By breaking down development into well-defined features, FDD enabled systematic planning to allow developers to capture requirements and hence design interactive content and real-time feedback for a sign language application. The integration of gamification elements further enhanced learner engagement and motivation. Technological implementation using Android Studio and Firebase supported real-time interaction and personalized progress tracking. FDD's feature-centric methodology proved particularly useful in managing assistive educational applications. The success of LearnBIM highlights the potential of applying FDD in accessibility-focused mobile solutions. Ultimately, the application meets both functional and non-functional requirements, contributing to inclusive communication and bridging the gap between the Deaf and hearing communities. In order to further enhance the LearnBIM application and make it more comprehensive for users, several improvements are proposed for future development. One enhancement involves the introduction of voice-guided navigation or an AI-powered virtual assistant, such as a chatbot to provide users with real-time verbal instructions, respond to frequently asked questions, and guide users

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through sign language activities. This feature would make the platform more engaging and offer a better interactive learning experience. Another possible upgrade is to involve and expand the content with conversational sign language modules, covering topics such as greetings, making requests, expressing emotions, and everyday dialogues like ordering food or asking for directions. This would benefit learners seeking to achieve greater fluency in Malaysian Sign Language.

6. ACKNOWLEDGEMENT

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7. CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

8. AUTHORS' CONTRIBUTIONS

Noorihan Abdul Rahman: Conceptualisation of the Feature-Driven Development; **Ainun Mardeya Mohamad Kasmani**: Implementation of LearnBIM application; **Nor Asma Mohd Zin**: Testing LearnBIM design; **Zuriani Ahmad Zukarnain**: discussion testing.

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