

## **ALBMAD: A Mobile App Development Approach**

**Anil Patidar<sup>1</sup>, Ugrasen Suman<sup>2</sup>**

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**Abstract:** Mobile apps are gaining popularity at an accelerated pace, which has led to a rise in demand for support concerning to Mobile App Development (MAD). The necessity for streamlined and effective MAD approaches has arisen in response to the sector's meteoric growth in the past few years. By combining the best attributes across various approaches, and tools/ techniques operated in MAD industries, an approach is required to improve adaptability, productivity, performance, and customer desires. The intention of the presented research is to gain modern insights towards MAD and propose an innovative approach that we referred to as Agile-Lean Based Mobile App Development approach (ALBMAD) for MAD. ALBMAD draws upon and improves upon the aspects of the scrum, kanban, extreme programming (XP), and lean methodologies. Furthermore, ALBMAD utilizes an iterative process at requirement gathering stage that refines the customer's ideas till it appears excellent. Teams working on MAD might benefit greatly with the advised approach, which has the potential to increase the apps' effectiveness, speed, and success as a whole.

**Keywords:** Agile, Kanban, Mobile app development, Scrum, XP

### **1. Introduction**

The need for mobile apps has grown dramatically in modern and technology-driven society. Mobile apps have entirely changed our approach to how we engage with the globe surrounding us, from conversation and entertainment to commerce and money management [1]. Convenience is one of the main needs that mobile apps address. As smartphone usage increases, users are looking for apps that can expedite operations, provide fast access to different services, and simplify difficult activities. Mobile apps offer a smooth experience that saves precious time, whether it's request for an item/service, calling a cab, or handling individual finances [2-3].

As reported by statista.com, 3.55 million mobile apps were available to Android users throughout the 3rd quarter of 2022. With almost 1.6 million iOS apps offered, the Apple app store became the second-biggest app marketplace. The total number of mobile app downloads globally is projected to reach 299 billion annually by 2023, up from over 247 billion downloads during the year 2020 [4-5]. This much quantity of mobile apps creates a competition in between the app developers/industries due to the same-featured mobile app availability and app users are independent to choose in between these apps according to their convenience and need. Therefore, in order to maintain their leadership position in this highly competitive marketplace and provide outstanding solutions, mobile app industries must adhere to

an effective approach [6-7].

Technological advancements and the rising demand for apps with additional capabilities and features are causing the mobile app market to expand quickly. As a consequence of this, the app development industries must meet challenging time-to-market requirements in order to deliver the desired product in an extremely competitive marketplace. To obtain an advantage over their competitors, industries strive to deploy their apps earlier than competitors. Thus, developing an appropriate app development approach is crucial for survival. It has shown by recent researches that agile-based methodologies, as opposed to traditional methodologies, are best suited for creating mobile apps [6, 8-9].

Developers as well as industries are continuously facing pressure to provide top-notch apps as quickly as possible because the mobile sector expands at an unprecedented pace. Agile development approaches supply an iterative and flexible techniques, allowing teams to evolve according to varying needs, enhanced communication, and eventually produce acceptable mobile apps [6, 10]. This research intends to come up with a new MAD approach that has the potential to cater the expectations of industries and users.

The subsequent sections of this paper are presented as follows. The review of literature is presented in Section 2. Section 3 deals with MAD domain experts' surveys. In Section 4, the ALBMAD is described. Section 5 describes about phase-wise supplements and practices for ALBMAD. The discussion regarding ALBMAD is stated in Section 6. Section 7 shows the comparative study between ALBMAD and existing approaches. Conclusion and future work are provided in Section 8.

<sup>1</sup> Research Scholar, School of Computer Science and Information Technology, Devi Ahilya Vishwavidyalaya, Indore, Madhya Pradesh, India

<sup>2</sup> Professor, School of Computer Science and Information Technology, Devi Ahilya Vishwavidyalaya, Indore, Madhya Pradesh, India  
Corresponding Author Email: anilpatidar07@gmail.com

## 2. Literature Review

The production of high-quality apps depends heavily on the appropriate development approach. Following two subsections provides the essential insights regarding the importance of an innovative Agile-based MAD approach.

### 2.1. Review in Favor of New MAD Approach

In this subsection, a few of the studies are described that agreed with the necessity of an innovative approach for MAD. Conventional software creation methodologies with the capabilities they have at present are not entirely transferable towards the MAD field [11]. As stated by several researchers, there is a desire for MAD to take an innovative approach in order to create valuable apps and get succeed in today’s competitive marketplace [1, 7-8, 10, 12-19]. In an existing research investigation on the MAD, researchers identified compatibility, user experience, change management, testing, and fragmentation, as typical problems [20]. In order to ensure successful and efficient mobile app creation, the research advises professionals to concentrate on these issues in business as well as academia. An SLR of existing software building approaches was conducted, that indicates there is a need for a standardized

approach for MAD [21].

In present scenario, the desires of forming an improved and novel MAD approach are due to the various facts such as unexpected deliveries of smart-phones and mobile apps, apps may interact with one another, regular alteration in necessities, consistent customer meetings, quick development cycles with committed timelines, technological evolution, etc. [4, 6-7, 9-11, 14, 22-25]. Therefore, in order to maintain the leadership position in this highly competitive marketplace, and deal with above issues concerning about to provide outstanding solutions, mobile app industries must adhere to an effective approach.

### 2.2. Review of Agile-based MAD Approaches

Agile software development approaches initially appeared in the year 2001 [26]. Agile practices were initially presented in 2004 in order to develop mobile apps. According to the findings of several researchers, agile-based techniques are well-suited to MAD since these facilitate more efficient and lightweight development [11-17, 22]. The literature presents a few app development models/approaches that include the idea of agile methodologies. In the table below, we’ve outlined a few of them.

**Table 1.** Review of agile-based MAD approaches

<i>Paper Type</i>	<i>Description of Paper</i>	<i>Gaps Identified</i>	<i>Agile Technique Used</i>
MAD Approach [12]	A new concept ‘architecture line’ is introduced, whose aim is to create an app framework that helps in future developments.	This scheme is not fully defined; therefore, it can’t be utilized in practice.	XP, Crystal
MAD Approach [14]	Hybrid Method Engineering (HME), which captures most of the issues identified in related work in this field.	The methodology is still at a high level, and no specific tasks for the identified stages have been provided.	ASD
MAD Approach [27]	Mobile Application Software Agile Methodology), which provides approach for MAD.	This work lacks case study in real-world environment.	XP
Support Tool [28]	Suggested some major improvements in Mobile-D approach.	The work requires experimental validation, and extensive work with a multidisciplinary expert team.	No one specific
Integrated Approach [15]	The approach integrates Scrum and Lean Six Sigma (LSS) called SLeSS. Scrum and LSS focuses on project management and approach improvement, respectively.	A case study for the implementation of proposed approach in MAD company is also presented without any report of its utilization.	Scrum
MAD Model [10]	Addressed challenges for MAD under fast paced market and volatile requirements. And drafted their own model.	Validation model was based on empirical data or interviewed data.	XP, Scrum, Kanban
MAD Approach [29]	An approach with best of both traditional and agile approaches is proposed to solve the	Only first four stages of proposed model are presented, rest of three stages are remains for future work.	No one specific

	difficulties of peoples purchasing pharmaceutical products.		
MAD Framework [19]	A framework which is based on scrum, that takes into account the characteristics, unique requirements, and difficulties of MAD.	Framework was used in a classroom setting. In addition, no user testing, and no knowledge of the iterative method.	Scrum

Based on our assessment of the pertinent literature, we are able to assert that the examined works make a contribution in MAD, but they have some issues such as incompleteness in proposed approach [12, 14, 29], lacks case study [27], lack of experimental validation [10, 27-28], and unavailability of report of utilization [15]. Only one of the MAD research [10] looks into how mobile apps are created in the mobile industries without any input from academic environments. Mobile industries and researchers need to implement procedures for development that encompasses additional benefits of modern agile approaches as mobile apps become more complicated and crucial. As stated in [21], the absence of frameworks, tools-support, models, as well as obstacles in design and interface seemed major roadblocks for mobile app companies, and therefore suggested the development of a new model to facilitate the improvement in MAD.

The objective of our research is to consolidate the best practices utilized by academic researchers and industry sector professionals into a unified approach. We must take into consideration and explore agile methodologies that could potentially be enhanced for developing apps for mobile devices.

### 3. Survey of MAD Domain Experts

In-depth interviews were conducted with professionals in the fields of MAD and software development, and also with academic researchers. During the interview process, we asked questions that are both open and closed-ended. The responses of open-ended queries we get with interviewers only. To get started with our review of the survey data, we first looked at each respondents' opinion independently, afterwards looking at the respondents' opinions as a whole.

#### 3.1. Questionnaire and Respondents

The questionnaire is divided into three main sections i.e., professional details of respondents, current trends in MAD and the role of agile approaches in MAD, and how MAD works in real scenarios. Each section contains different set of questions to get the more detailed insights to achieve the moto of its title.

For the purpose of obtaining the answers of prepared questionnaires, there are 92 invitations were sent as well as 9 interviews are conducted with mobile app domain experts. About 51 replies completely, and 7 were discarded due to their incompleteness. Out of these 51 respondents 39 experts

belongs to software/ mobile industry and remaining experts from academics. Also, the interviews were carried out to glean richer insights, in which 6 of the interviewees come from industries, and 3 are from academics.

#### 3.2. Professional Details of the Respondents

There are 5 questions that linked with this section for acquiring the specifics of different respondents. The professional details of the respondents are demonstrated below in Table 2.

**Table 2.** Professional details of the respondents

Q. No.	Questions	Possible Responses	% of Votes
1	Industry type	Mobile/Software Industry	75.00%
		Academics	25.00%
2	Your role in current industry	Business Analyst	5.00%
		Designer	10.00%
		Developer	15.00%
		Tester	10.00%
		Quality Analyst	5.00%
		Team Lead	13.33%
		Project Manager	11.67%
		Agile Coach	3.33%
		Researcher	25.00%
3	Experience in MAD	< 1 Year	8.33%
		1 to 5 Years	30.00%
		6 to 10 Years	38.33%
		11 to 15 Years	21.67%
		> 15 Years	1.67%
4	Total work experience in your industry	< 1 Year	3.33%
		1 to 5 Years	31.67%
		6 to 10 Years	36.67%
		11 to 15 Years	26.67%
		> 15 Years	1.67%

5	You are an expert in	Business Analysis	8.33%
		Designing	15.00%
		Developing	23.33%
		Testing	15.00%
		Quality Analysis	5.00%
		Project Management & Leadership	25.00%
		Agile Specialty	3.33%
		Other	5.00%

As revealed in Table 2, for obtaining the MAD perceptions the surveyors belong to MAD industries, together with academia. Furthermore, most of the respondents have their involvement in MAD with more than 5 years, and they experts in various phases of MAD lifecycle.

### 3.3. Current Trends and Impact of Agile Approaches Used in MAD

The current state of MAD is extremely dynamic and rapidly evolving. Markets always change with emerging innovations and trends. In Table 3, the latest trends in MAD and the involvement of agile approaches in MAD are offered.

**Table 3.** Current trends in MAD and the role of agile approaches in MAD

Q. No.	Questions	Possible Responses	% of Votes
1	Is your company dealing with MAD?	Yes	71.67%
		No	13.33%
		Occasionally	15.00%
2	What is the specific domain of your work?	MAD	68.33%
		Software Development	13.33%
		Both	18.33%
3	In the past 3 years, what number of different mobile apps have you contributed to create?	None	13.33%
		< 5	15.00%
		5 to 10	23.33%
		11 to 20	26.67%
		> 20	21.67%
4	Does the approach of MAD at your company typically involve agile approaches?	Yes	65.00%
		No	13.33%
		Occasionally	21.67%

5	Which agile approaches are used for MAD in your organization? (Please select all applicable options)	None	8.33%
		XP	30.00%
		Scrum	60.00%
		Kanban	28.33%
		Crystal	5.00%
		Lean	21.67%
		Combined Agile Approach	26.67%
		Depends on the need	10.00%
		Other	3.33%
		6	What are the reasons of selecting agile approaches instead of other approaches? OR Why agile approaches are suitable for MAD? (Please select all applicable options)
Fast delivery	48.33%		
Cost effective	21.67%		
Stakeholder involvement	60.00%		
More reliable	45.00%		
Less risky	58.33%		
Suitable for MAD	81.67%		
Improved product	63.33%		
improved client loyalty	60.00%		
Other	0.00%		
7	Are you with the opinion that agile methodologies are beneficial to MAD?	Yes	75.00%
		No	3.33%
		Occasionally	21.67%
8	Which agile best practices used by your organization for MAD? (Please select all applicable options)	Cooperation between clients and other stakeholders	63.33%
		Daily standup	81.67%
		Effective team communication	78.33%
		Self-organized team	75.00%
		Tasks prioritization	80.00%
		Continuous integration and deployment	68.33%
		Development progress transparency	60.00%
		Other	18.33%

9	Is there is any difficulty in applying the practices and principles of agile methodologies? (Please select all applicable options)	Lake of time	25.00%
		Lake of resources	30.00%
		Lake of proper planning	21.67%
		Lake of coordination between team members, as well as with clients	41.67%
		Inadequate and uncertain requirement from customer	30.00%
		Changing requirements from customer	45.00%
		Lack of required documentation	21.67%
		Other	5.00%
10	What is the size of the MAD team in your organization working on a particular app	< 5	38.33%
		6 to 10	45.00%

development project in general?	11 to 20	13.33%
	21 to 30	3.33%
	31 to 50	0.00%
	> 50	0.00%

Majority of respondents voted that agile approaches are appropriate for MAD, and also, they practice agile approaches for MAD. The scrum is among the most well-known approach in MAD. XP, lean and kanban are also famous approaches in MAD with good utilization share. In addition, some industries take advantages of combined agile approaches.

With this survey we have received various complements from professionals such as appropriate approaches for MAD, and various practices, inputs, outputs, and tools, that we have exploited for the accomplishment of various activities of our proposed approach ALBMAD. These findings are brief in Table 2, Table 3, Table 4, and Table 5. Moreover, one of the most important section of findings of this survey that is “How MAD works in real scenarios” is clubbed with Section 4 according to their importance for fulfilling different activities of ALBMAD.

#### 4. ALBMAD Approach

ALBMAD towards the creation of mobile apps is proposed after the evaluation of different findings of surveys and interviews that were carried out. This approach takes advantages of both real-world practices such as academic’s as well as industry’s most successful practices as suggested by experts, and practices that works finest with an agile environment as suggested in literature. It would appear that approaches such as scrum, XP, kanban, and lean are most essential in order to form an efficient MAD approach, as revealed by both literature review as well as survey sources. You can see the recommended approach ALBMAD, exposed in Figure 1 below.

An efficient approach for MAD requires a degree of

adaptability in taking advantage of and making use of the many approaches available. The ALBMAD, is an essence of finest practices applied by scrum, XP, kanban, and lean methodologies, and tools/techniques advised by professionals of industries and academia.

The entire lifespan of the ALBMAD is broken down into three phases, which are denoted by preparation phase, main phase, and post phase, accordingly. The succeeding section offers an in-depth explanation of ALBMAD. The responses concerning with each activity performed during MAD are included parallelly to phases of ALBMAD. Subsequently, it is essential to make a reference to the phase-wise supplements, and effective practices exposed in Table 4, and Table 5, respectively, in order to excellently practice the ALBMAD.

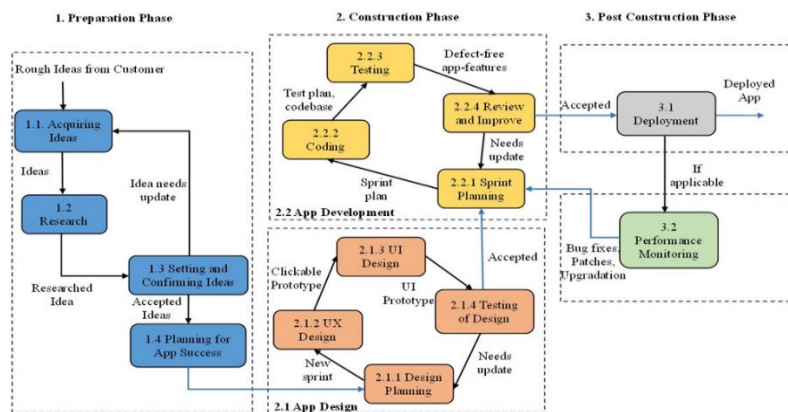


Fig 1. Proposed Approach ALBMAD

## 4.1. Preparation Phase

The MAD begins with preparation phase. The primary focus of this phase is to gather and set the ideas for building app, research the market, and plan for app success strategy. The four steps that make up this phase are described in turn below.

### 4.1.1. Acquiring Ideas

The mobile app developers begin the process of MAD with an idea in hand which their customers suggest and almost every idea is created to solve some problems. Identify the people who have a vested interest in seeing the mobile app succeed. Gathering user input requires setting up meetings, talking to users (through interviews, questionnaires, or just plain old-fashioned brainstorming), and creating user stories. The ideas/needs acquired previously may be well established, but in most of the cases the customers having no obvious insights about the practicability of idea. Therefore, this necessitates more investigation of the acquired ideas.

### 4.1.2. Research

The process of switching from the ideas to a mobile app is initiated from an exhaustive investigation on those ideas. In this process, research is prepared on primary objectives, problems to be dealt with and feasibility of solutions, target users and market, review of competitive mobile apps, app features, and extraordinary app features offered that catch the attention of app users. The review of competitors is very beneficial in terms of getting an idea about how they have provided the solutions of problems and as well, you can obtain some insights of budget and timeframe by exploring their mobile apps, websites and other resources.

### 4.1.3. Setting and Confirming Ideas

Once the market research about the idea is in hand, now this is the time to setup the app objectives. Based on the earlier obtained essential insights the idea is refined and objectives are shaped. These objectives are then discussed with other team members, potential users, and experts and their suggestions are incorporated to further refine the objectives. At this stage we can also confirm app objectives, it's working and usability by creating minimum viable product (MVP). Even if the objectives have any issues, then research can be done again. The final objectives further discussed with the customers and based on acceptance criteria and their feedbacks (if reasonable) the objectives are improved and confirmed finally.

Here, an iterative approach has been established for efficient acquiring of ideas, their validation, and closing approval from stakeholders.

### 4.1.4. Planning for App Success

The first and foremost thing is to prioritize the requirements based on the customer's opinion with their probable time to complete, and get the skilled team members which will provide the victory over these requirements. This step deals with to decides on important factors such as look and feel, skills required, customer support, value to target audience, tools, technologies and platform, security, app scale, return on investment, time and budget, etc. which affect the MAD and assist in achieving the success over the app targets. All these factors are necessary supplements for establishing a decent app development plan.

**Professional's Responses:** For the purpose of initiating the MAD and achieving the awareness about requirements gathering and its justification, there are 9 questions are planned. The probable reactions of the respondents are offered here. The MAD initiates with an exhaustive investigation on customer ideas, this is favored by 81.67% respondents. To get requirements from users the most famous technique is interviews as suggested by 60% respondents, surveys is on second choice with 41.67% responses, 38.33% in favor of brainstorming, and document analysis, prototyping, use-cases and scenarios, and interface analysis are some other significant techniques. After gathering the rough ideas/needs from customer, 91.67% respondents said that market research being necessary to verify that the app ideas fulfilling the desires of present market. For performing market research most renowned method is competitor or existing app analysis, latest market trends analysis is next one, probable end-user review is third choice, and experts review method is spent very less.

According to the 75% that were surveyed, it is necessary to get feedback from customers after market research of idea has completed, 10% do it occasionally, and there are 15% that disagree with this. In context of decision making for finalization of requirements/ideas, most of the responses in favor of customers and verifying minimum viable product, and opinion of others supports decision of other stakeholders and experts.

The project and team management are one of the crucial parts of MAD. In order to do this, respondents employ a variety of tools. The majority of its customers rely on Jira, a popular system for tracking and managing projects. Wrike, Asana, Todoist, Basecamp, Teamwork, and Trello are also well-known alternatives that can be used for this purpose, as per the respondents' views. As soon as the finalization of app ideas is done, respondents plan for mobile app's success by performing requirements prioritization and establish app development plan as a most significant task, then assemble essential tools/techniques and skills, afterward decides on app security, app scale, look & feel, time & budget, customer support, value to target audience, return on investment, etc. In favor of thorough documentation

necessity of preparation phase 43.33% respondents voted, 45% said that it is sporadically required, and remaining elected in opposed of it.

## 4.2. Construction Phase

After the effective accomplishment of preparation phase, the subsequent stages are to design, develop and test the intended app ideas.

### 4.2.1. App Design

Here, it is desirable to build the visual and design of what we have gathered and planned in previous steps. With the help of app design, designer confirms how mobile app will look and work. The design step has three significant parts- planning, user experience design (UX) and user interface design (UI). Detailed user research and prioritized business objectives will be necessary as we map out the plan to execute, necessary expertise, tools, and other resources.

UX Design deals with producing a system that offers the finest experience to their app users. The main attention of UX is on users and their journey over the app, and consequently it decides the app success. There are 3 main sub-parts of UX design- information architecture (IA), workflow, and wireframe. IA empowers the users to search what they desire with the app. With IA, designers organize and label the content, therefore, the app have more utilizable and comprehensible to its users, while amplifying the users' experience. When creating the architecture of the app, the workflow influenced by the data that will be collected for users, the data gathering process, user collaboration with the app, and different kinds of people and privileges which are involved in app development process. Workflow make it possible to see every interaction a user might have with the app's interface and menu system. Wireframe is one of the methods of conveying content to be design. It provides a concept of the system's functionality and improves the understanding of how it works. Think of a wireframe as a testing ground where one can test their thoughts, and analyze potential interactions. Developing a clickable prototype allows us to put this wireframe to the test.

Users communicate with mobile app through the UI. UI incorporates icons, buttons, colors, animations, menu-bars, screen layouts, and even it contains each and every interaction that you can imagine with app. In essence, it integrates each component of an app and provide a sense of coherence. Under UI design, designers create style guides, and mockups. The design standards that will be used to create the apps are contained in a style guide and these rules will cover branding standards, navigation icons, and app design norms. Style guides support uniformity within mobile app and guarantee that the appearance and feel are constantly in harmony. It improves the communication between designers and developers. Mockups are basically the finished visual representations of the app, and they are

produced by integrating the style-guides into the wireframes. Prior to moving on prototype, designers will also iterate here to incorporate feedback from stakeholders. To ensure that the mobile app offers a smooth experience to its users, the app designer develops a clickable prototype afterwards the approval of wireframes and mockups. With prototyping it is possible to decrease the potentials such as, design faults, discrepancy between the client and the designers, etc. at earlier in design phase.

It is essential to run usability & user testing, write user stories, and verify the app prototype with various user groups. In order to acquire better and optimal results, you can also conduct user tests at each sub-part of UI-UX design process.

**Professional's Responses:** Building the visuals and designs of what we have gathered and planned in previous steps is the moto of design phase. There are 13 questions are prepared to accomplish the design phase goals. Information architecture (IA), Workflow, and wireframe are some crucial elements of UX design. IA is necessarily formed by 48.33% respondents, 28.33% do it occasionally, and remaining are against to create it. Wireframes show structure and stable components without interactivity. Interactions are described deeply through flowcharts; however, the user's scenario is ignored. In accordance with the most of participants, testing of wireframe and workflow is required. The inevitability to create clickable prototype for testing wireframe/workflow is favored by 41.67% respondents, 28.33% infrequently follow this, and 30% refuse to go along with. The vast majority of designers make use of Adobe XD, InVision, Sketch, and Figma to create and test workflow, wireframe, clickable prototype, and these tools are also utilized to switch from a wireframe to a mockup. Paper and pencil, and whiteboards serve a similar function in many MAD industries.

Pleasant user experiences are the result of well-designed user interfaces, and they can increase engagement. As a result, users may become more involved with app content, staying on your app or enjoying it for longer. In UI design, the most vital tasks include building style guides, mockups, and prototypes. Most of the respondents (58.33%) creates style guides for uniform design standards, 31.67% sometimes creates the same, and 26.67% not in favor of this. After the generation of mockups 41.67% respondents create prototype, 35% occasionally create this, and remaining are against to do this. Most of the respondents favored that once UI design phase finished it is necessary to get feedback from customers concerning to design success. In addition, if there are any updation proposed by customer, then 51.67% respondents incorporate those modifications, 23.33% not respond to these changes, and remaining do it occasionally. In context to the cost of modifications, 56.67% respondents

impose a surcharge on it, and 43.33% stated that added cost depends on criticality of changes.

#### 4.2.2. App Development

The objective is to produce the finest version of the app you have in mind while staying within the parameters of cost and timeline. The technology stack we outline at the project's inception is used for development. Alongside UI/UX designers and quality assurance engineers, software engineers work together. Depending on the strategies and models of collaboration offered by organization, the team members will report every-day or weekly and hold regular meetings with a client along with a project manager. Agile technique places more emphasis on the development phase, which is where your app is really coded. The process of creating an app must be iterative, with each task to be developed is divided into manageable milestones. Here, the iterative process broken down into four major sub-processes, that encompasses planning, coding, testing, and review and improve.

In the planning stage, the tasks that must be completed in the developing phase for the current iteration are outlined first. The goal of each task, the necessary conditions, and the anticipated outcome for this iteration are all clearly stated. Here, the development team must choose whether to modify the existing code or write novel code specifically for the task at hand.

The front end, back end, and APIs are 3 aspects that developed as part of the typical MAD approach. There will likely be builds available for customers to test at various points throughout development. Analytics should be incorporated at this step, that helps businesses to track and know their user experiences and interactions with the apps. Users will interact with your app directly through the front end, which is the user interface. Firstly, you need to select the type of app platform you will be creating for. There are three main types of platforms for MAD. Firstly, the native apps work only with a particular operating system and platform, such as android, iOS, windows, symbian, and blackberry. Native apps are inclined to provide high performance, good user experiences, and full freedom on app usage. Hybrid is the second platform type, that combines elements of native and web apps. They use cross-platform technologies like HTML5, JavaScript, and CSS since they need to function across several platforms. Hybrid apps provide for quick and simple app development as well as smooth upgrades. Third type is web apps, which are created similarly to websites, work in browsers, and have a similar interface to native apps, but they are created using various web technologies, including HTML5, CSS, or JavaScript. These apps can be created more quickly and affordably, and they are simple to adapt to different platforms.

The backend server will be responsible for maintaining the mobile app. It offers assistance for databases along with server side operations. At this point, the app's server side assets need to be set up and evaluated alongside its other features. Through the assistance of an API, an app may exchange data with another apps and servers. APIs don't represent servers or databases themselves but rather the code that allows for interaction with them.

The failure to find and fix defects during testing has an immediate effect on the final product. Latest research has shown that users discovered and reported forty-four percent of the total app bugs, and for forty-seven percent of apps additional effort is required throughout testing. The popular testing approaches for verifying the functionalities of the mobile apps are usability, performance, user-acceptance, regression, unit, and integration testing. For smooth conduction of testing automated tools are also popular.

Each iteration concludes with a group discussion on which modifications still need to be addressed. Towards the conclusion of every iteration during the agile development process, the client receives the app's finalized features. Once the mobile app has been developed, novel functions are introduced as soon as possible. The tasks completed in an iteration is continually evaluated to enhance the quality of the ultimate result.

**Professional's Responses:** In this phase of MAD, the finest version of app is created, and actually, it is the beginning stage of MAD. We have asked 15 questions for getting better development insights, their replies are accessible. This stage commences with sprint preparation, as per the most of respondents. It is more beneficial to create app with quick iterations as suggested by 60% respondents, 11.67% responses in contradiction of this, 28.33% argued that in some cases size of app matters. Some of the respondents use tools such as Zeplin, Sketch, Abstract, and InVision DSM to make sure that the design phase leads successfully into the development phase. Native, Web, and Hybrid are the platforms classically employed for developing an app, and Native platform is the most famed among all.

In regards with language for API development most renowned are JavaScript, Python, PHP, and Java. Based on the preference of respondents some of the well-known coding tools are Android Studio, Xcode, Visual-Studio Code, Sublime Text, Xamarin, AppCode, Adobe Phone-Gap, Ionic, React Native, and Sencha. The hosting environment selection based on the customer's preference is done by 58.33% respondents, 23.33% sporadically do this, and the rest of them disagree with this. Cloud vendors such as AWS, GCP, and MS Azure, are typically utilized to host the APIs and storage databases. When it comes to cloud providers, AWS is by far the most widely used. The concept of code reusability is promoted by the majority of respondents. The evaluation of sprint outcomes performed



by QA team and project manager as recommended by vast majority of respondents. There are some responses that favored to communicate assessments among fellow developers or clients throughout app development.

The inevitability of delivering finished functionality to customer after each iteration ends is suggested by 45% respondents, 28.33% do it sometime, and 26.67% not agreed with this. The popular testing approaches for verifying the functionalities of the mobile apps are usability, performance, user-acceptance, regression, unit, and integration testing. Appium, and Espresso are the most famous tools for performing automated testing. In addition to these primary tools, respondents furthermore make use of tools such as XCUITest, Robotium, Xamarin, Google firebase, Selendroid, and Katalon. In concern to the role of UX/UI designers in the verification of implemented app features is crucial as advised by 48.33% respondents, 40% involve them infrequently, and 11.67% disagreed with this.

#### 4.3. Post Construction Phase:

Here, final app made accessible to users, as well as evaluated to make sure it is operating correctly. Once stockholders satisfied with the app's performance, deployment team are able to publish it live to the marketplace from which users may download it. One can accomplish this either by deploying APIs on an elastic production platform or releasing them on a marketplace. It's inevitable that users will provide the criticism and comments. Now that the mobile app is live, it's essential to keep an eye over it in order to see how it's performing. Never neglect to monitor the quantity of regular users, the app's ranking and critiques, malfunctions, bugs, queries from consumers, and how complete app performing. Then it is

must to refine the app over the course of time through performing that.

**Professional's Responses:** The reactions of respondents associated with this phase are gathered via three questions. The process of releasing a mobile app begins with the packaging the app code in an appropriate manner. Additionally, it is the responsibility of team to establish and set up all required offerings, databases, and security measures. Also, the app must be mobile-friendly. The deployment of the APIs in production environments is done by 43.33% respondents, more than half of the respondents claimed that it depends on the service agreement, and 5% against of this.

Users are finally able to access app's functionalities. Naturally, they will provide some comments and suggestions. The reactions of respondents associated with this phase are conveyed here. More than four-third of respondents reported that the conduction of app performance tracking depends on service agreement. Based on the preference of respondents some of the renowned performance tracking tools are New Relic, Firebase, AppDynamics, Dynatrace, Crashlytics, Splunk, Google Analytics, DataDog, Prometheus, and Sentry.

#### 5. Phase-Wise Supplements and Practices to ALBMAD

This section deals with the reactions and comments encountered from the respondents in context to free-form questions concerning about phase-wise supplements, and effective practices. Table 4 comprises the phase-wise supplements which includes vital inputs, probable outputs, and tools to be employed.

**Table 4.** Phase-wise supplements for MAD approach as per respondents' views

<i>Phase Name</i>	<i>Required Input</i>	<i>Generated Output</i>	<i>Tools Used</i>
<b>Acquiring Ideas &amp; it's Research</b>	Rough ideas, Business needs	Market research, User stories, Well-formed ideas	Trello, Slack, Google trends, Google forms, Interviews, Surveys, Brain storming
<b>Setting &amp; Confirming Objectives</b>	Market research, User stories, Well-formed ideas, Stakeholder feedback	Final ideas/objectives	Figma, User testing, Google trends, Google forms
<b>Planning for App Success</b>	Final ideas, Stakeholders feedback	Time, budget, resource prediction report, Prioritized needs, feature release plan	Jira, Asana, Wrike, Teamwork, Trello, ClickUp
<b>Design Sprint Planning</b>	Prioritized needs, user research, feature release plan, Stakeholder suggestions	Design plan, design resource plan	
<b>UX Design</b>	User personas, User flows, Visual design guidelines, Brand assets, Final ideas	Wireframes, Prototypes, Information architecture	Sketch, Adobe XD, Figma, InVision, Balsamiq, UXPin, Marvel

<b>UI Design</b>	Prototypes, Style guides, Interaction and animation guidelines, UI assets	UI, Style guides, Clickable prototype/app design	Adobe XD, InVision, Sketch, Framer, Proto.io, Marvel, Figma
<b>Development Sprint Planning</b>	Product backlog, app design, estimates, criteria for acceptance, probable risks	Development plan, development resource plan, sprint backlog	Jira, Asana, Wrike, Teamwork, Trello, ClickUp
<b>Developing</b>	Finished user stories, criteria for acceptance, UX-UI design components, technical specifications, sprint backlog	Codebase/ source code, working app, testable artefacts, scripts for deployment	Android Studio, Xcode, Visual-Studio Code, Sublime Text, Xamarin, AppCode, Adobe Phone-Gap
<b>Testing</b>	Test plans, test artefacts, user stories, codebase	A top-notch app/ feature, defect reports, test cases, patch reports	Appium, Espresso, XCUI Test, Robotium, Xamarin, Google firebase, Selendroid, Katalon, UsabilityHub, Maze, Testsigma
<b>Review</b>	Finalized App or particular feature, user stories, criteria for acceptance	Report for improvements/ suggestions	Testsigma
<b>Improve</b>	Finalized App or particular feature, Report for improvement	Improved & final app/ feature	
<b>Deployment</b>	Final app/ feature, Reports of test, deployment plan	Deployed app, logs of deployment, tracking data	Fastlane, AppCenter, HockeyApp, Fabric, Firebase
<b>Performance Monitoring</b>	Deployed app, defect/analytics reports, feedbacks	Fixed bugs, novel features, potential improvements	New Relic, Firebase, AppDynamics, Dynatrace, Splunk, Google Analytics, Prometheus, Sentry

These supplements contribute to improved MAD team experience while employing the ALBMAD. Table 4 deals with the phase-wise supplements which comprises vital inputs, probable outputs, and tools to be employed.

**Table 5.** Effective practices of scrum, XP, lean, and kanban

<i>MAD Phase</i>	<i>Scrum</i>	<i>Kanban</i>	<i>XP</i>	<i>Lean</i>
<b>Preparation Phase</b>	User stories, Sprint planning, Product & sprint backlogs	User stories, Kanban board	User stories, Planning game, Prioritize needs	Market research, MVP, Value process mapping, Kaizen
<b>Main Phase: Design</b>	Sprint planning, Daily stand-ups, Sprint reviews	Kanban board	Simple design	Kaizen

<b>Main Phase: Develop</b>	Sprint planning & reviews, Daily stand-ups, burn-down chart	Kanban board, Work-in-progress limits	Pair Programming, TDD, Continuous Integration, Refactoring	Kaizen
<b>Main Phase: Test</b>	Acceptance Criteria, Sprint review & retrospective, Testing	Kanban board	Testing such as automate, unit, acceptance, integration	Fail Fast, Kaizen
<b>Post Phase</b>	Sprint retrospective, Release burn-down chart	Kanban board	Version control, feedback & improvements	CI/CD, Kaizen

Table 5 concerned with the variety of practices employed by scrum, XP, lean, and kanban methodologies, among these practices most appropriate we have applied throughout the ALBMAD approach. In accordance with the team member's skill as well as the needs of the mobile app, they may opt the finest practices during every phase.

## 6. ALBMAD vs. Existing Approaches

Here, we will contrast our ALBMAD approach to other often used as alternatives. Communication, iterative progress, constant enhancement, and a concentration on the customer are at the forefront of the MAD approach, which is founded in this research. But alternative approaches, as incorporated in Table 6, may have distinct philosophies, procedures, and goals. Mobile-D emphasizes data-driven, optimized mobile apps. To find and fix security flaws and risks in apps, MASAM adopts a risk-driven strategy. SleSS is an expansion of scrum and lean ideologies. Whereas ALP is a progressive and iterative method for MAD that blends both lean and agile ideas, Mobile-Ilities focuses on the non-functional needs. How you go about things is going to be determined by the nature, scope, and purpose of the mobile app you're dealing with. We've identified the key distinctions and parallels among the ALBMAD and the existing approaches, which are summarized below in Table 6.

**Table 6.** Comparison between existing MAD approaches and ALBMAD

<i>Approach</i>	<i>Mobile-D</i>	<i>MASAM</i>	<i>SLeSS</i>	<i>ALP</i>	<i>Mobile Ilities</i>	<i>ALBMAD</i>
<i>Agile method</i>	XP, Crystal	XP	Scrum	Scrum, Kanban, XP	Scrum	Scrum, Kanban, XP
<i>Other method</i>	RUP	RUP, SPEM	Lean Six Sigma	Lean	-	Lean
<i>Combined agile methods</i>	Yes	No	No	Yes	No	Yes
<i>Experimental nature</i>	Yes	No	Yes	Yes	Yes	Yes
<i>Based on expertise</i>	Industry Experts	Industry Experts	Industry Experts	Industry Experts	No	Both Industry & Academia
<i>Approach Type</i>	Heavy Weight	Heavy Weight	Light Weight	Light Weight	Light Weight	Light Weight
<i>Project Management</i>	No	No	Yes	Yes	Yes	Yes
<i>Iterative cycles</i>	2	2	2	2	2	3

The goal of this approach is to combine the best features of many approaches to increase productivity, collaboration, and the final quality of the app as a whole. The specific problems that arise in various MAD scenarios make it difficult to choose the best approach. The overarching goal of this investigation is to arrive at an approach that incorporates consideration of nearly all the aspects outlined by Table 6. The recommended approach offers an adaptable collection of MAD procedures gleaned via an experimental strategy incorporating professionals from both academia and MAD firms. Furthermore, there are 3 iterative cycles are utilized during the whole MAD lifespan. One extra cycle formed for reattempting the ideas purification until, the finalized ideas not get generated.

## 7. Discussion

In this work, we have suggested a novel approach for MAD by fusing together a some of agile methods, such as scrum, kanban, XP, and lean. The goal of this approach is to combine the best features of many approaches to increase productivity, collaboration, and the final quality of the app as a whole. Following the scrum, the MAD approach is broken into manageable sprints, any one of which continue for a particular length of time. The team intends to employ a kanban board to manage work and discover obstacles throughout the various sprints. The superiority within the codebase will be ensured by the adoption of XP practices like continuous integration and testing. Furthermore, the entire team is being guided by Lean concepts to enhance efficiency, cut down on waste, and provide greater worth to customers. By doing continuous demos and revisions, it ensures constant customer and stakeholder participation, communication, and review throughout the whole development process.

The team can become better equipped to react towards altering needs and meet the demands of their customers by adopting this agile approach for MAD. ALBMAD borrows ideas from scrum, kanban, XP, and lean in an effort to shorten the development cycle and increase quality for mobile apps. ALBMAD is an extensive set of activities for MAD that can be implemented in a variety of settings; the aforementioned approaches were generated through an experimental approach which comprised with professionals from the academia as well as from MAD industries. During MAD requirements elicitation step, we have incorporated an iterative process that reattempt the ideas purification until, the finalized ideas not get generated. Also, analytics should be incorporated in mobile app during their development. This can analyze user experiences for business benefits, and better app updates can be generated.

## 8. Conclusion and Future Work

The primary objective of this study is to equip professionals working in the field of MAD with a thorough comprehension of the ways by suggesting an approach for MAD which incorporates scrum, lean, kanban, and XP concepts. Leveraging the benefits associated with each method, professionals may boost agility, productivity, performance, and user pleasure at every stage of the MAD lifecycle. The suggested approach is an extensive set of activities, and tools/ techniques which are followed by MAD professionals as well as by academia researchers. ALBMAD approach is proposed which consists of three phases; namely, preparation, construction and post construction phase and even these are broken down further. Here, we've put most of our effort towards the preparation phase activities, rendering things as effortless as practicable for MAD professionals. Also, an extra iterative loop is formed for retreat to ideas until it got finalized. In order to assist industries to accomplish their goals, and the academia researchers should adhere to the specified practices, and tools/ techniques for developing and releasing mobile apps. Going forward, we intend to verify the correctness of our discoveries and evaluate them.

### Conflicts of Interest

The authors declares that there is no conflict of interest regarding the publication of this paper.

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