OBJECT-ORIENTED DESIGN OF LEARNING APPS

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ABSTRACT

In the age of Apps, there has been a widespread proliferation of Learning Apps (LA). Almost every educational institution has been affected since the pandemic. The research indicates that such apps are highly effective for the so-called 'touch-screen' generation in a variety of contexts. Data on LA's performance show that they are associated with compelling increases in student achievement. Recognizing the significance, it is suggested that teachers and other caretakers become involved in this new trend of mobile learning. Despite this, experts generally highlight issues concerning their effectiveness. As a result, we observe the emergence of several design paradigms, having no or little theoretical bases. Even though businesses grow, and new tools and technology are developed, there isn't a good app design strategy based on accepted didactics. Realizing this, we suggest a Pedagogic-Object-Oriented Approach based on critical & qualitative review methodology to the design and development of LAs, building on the idea of IEEE learning objects and the success of the object-oriented paradigm. Current app developers may find the proposed method helpful as they strive to create really instructive and user-friendly apps for digitods students.

KEYWORDS

Learning App, App Ingredient, Object-based Approach, Design.

1. INTRODUCTION

Today's learners are known as digital natives or digitods learners and sometimes we called them the 'touch-screen' generation [16]. Because these touch-screens provide some unique affordances as it was never seen before that. Learning apps or educational apps are one of the supporting logistic facilitators of these devices. An LA is generally a small, web-based or downloadable software application that typically works on any portable device and is designed to support learning [14, 17]. These applications on touchscreen devices have the potential of revolutionizing early childhood education and help to build a strong base for lifelong learning in the twenty-first century [14].

LAs can improve existing students' experiences when they appropriately utilize these apps. A similar evidence found in literature that is data on LA's performance show that they are associated with compelling increases in student achievement; particularly, the average app-based curriculum increases achievement by 165% of expected student growth. Moreover, when such apps are developmentally appropriate and the technology is used properly, we witness a large list of their benefits in a variety of areas, including language, fine motor, cognitive, and social abilities [4, 15]. A study conducted by Nikolopoulou [15] on a comparison between app learners (who used apps in their learning) and non-apps learners (not utilise apps in their learning) found

app-learners gained significantly better learning gain than the other group. Amasha et al. [16] findings were similar to Nikolopoulou [15] though they did their learning comparison on mathematics discipline.

Most importantly, these apps place students at the centre of education rather than the teacher [16]. Recognizing the significance, it is suggested that teachers, curriculum planners, policymakers, administrators, and caregivers become involved in this new trend of mobile learning. Despite of these aforementioned significance, there is some research-based evidence behind the fan following of these software in the current scenario. Among the reasons are the inherent appeal of such apps, their unique affordance, the ongoing demand for technology integration by educational fraternity, and the proliferation of technology. Unfortunately, such computer software i.e. LAs do neither come without drawbacks nor do so in future. However, with advancement all the way, the LA systems must emerge and mature with time.

The range of issues associated with app selection and their quality, the lack of concrete tools for evaluating such apps, problems with collaboration between app developers and educational experts, problems with personal prospects, and problems with app testing (see later). Apropos to these, there appears a need for a thorough, coherent, workable, and design-based strategy. A design of this type must necessarily and methodically be built around all of the established instructional ingredients. We propose an architecture, based on the object-oriented paradigm as a foundation for instruction in the creation of mobile learning apps in light of the prime realisation of the ample scope for content experts creative independence. To accomplish this, we first compiled a list of essential app ingredients based on a thorough review of the relevant literature, a qualitative analysis of some learning apps (that is, what should be included in a genuine learning app), and other such observations. To achieve this research objective, we divided our paper into six sections: introduction (current), literature review, challenges ahead, essential learning app ingredients, the blueprint of the object-based design approach, and conclusion.

2. LITERATURE REVIEW

Since a few years ago, there has been a significant increase in the development of educational applications. As of January 2013, there were over 775,000 apps available, and educational apps rank as the second most popular category in terms of downloads [1, 2]. Later, this number was doubled, and LAs now account for roughly 16% of all apps in both app stores [3]. The majority of app stores only had two sorts of educational apps: pre-schoolers and language learning. Vaiopoulou et al. [5] revealed that preschool (toddler) learning apps cover a major portion of the app market. On the other hand, a slew of concerns has been voiced about their (LAs) poor design patterns, particularly in the selection of their instructional elements. In light of this, we examined several important studies on learning app instructional ingredients (parameters).

Green et al. [6] proposed seven key instructional design factors for creating an effective app evaluation rubric based on four design cycles. They revealed the most relevant literature in cycle one, and then collected key qualitative data in the following three cycles. Accuracy, curriculum-oriented training, inquiry and practise, authenticity, feedback, navigation, and learner-friendly instructions are some of the ingredients found in their app's development process. Meanwhile, these design criteria were assessed using a four-point Likert scale. The primary issue with their suggested app parameters was that they were exclusively applicable to science education applications.

In the same year, one more similar study was conducted by Al-Alwani [7] on assessing e-Learning content by approaching quality survey questions on seven pertinent criteria with assimilation of 42 e-Learning experts. Primary criteria set (subject specific & policies) included

content level (content quality & connection with curriculum), presentation tools (media, customization, and easy navigation methods), teaching methodology (incorporate feedback & evaluation), learner-friendly interface (ease of use & availability of help options), technical knowledge, and multimedia control as evaluation parameters for e-content. Similarly we have revealed some useful insights in the tabular form regarding existing app evaluation tools and techniques, especially their design classes.

For doing so we framed six columns in our literature review-based table including a list of included studies (S1 to S9), year of publication, evaluation tool proposed by included studies in form of rubrics or frameworks, targeted group or scope of a particular study, methods that have been applied while conducting their research, and most importantly their proposed design criterion.

Table 1. Selected studies targeting LAs design parameters

Studies	Year	Tool	Scope	Methodology	Proposed Designed Parameters
S1 [6]	2014	rubric	K-12	Review with 5-point Likert scale	Accuracy, curriculum-oriented, inquiry and practice, authenticity, feedback, navigation, and learners friendly
S2 [7]	2014	Framework	Higher education	Online survey + 42 experts cadre with 4 points Likert scale	Primary criteria, content level, presentation tools, teaching methodology, learner-friendly interface, technical knowledge, and multimedia control.
S3 [8]	2015	Rubric	Toddlers with LD	Online survey + 5 experts cadre with 5 points Likert scale	Clear & well-defined learning objectives, proper learning strategies, examples, practice, feedback, error reporting strategies, learners progress, navigation, motivation, multimedia stimuli, font style, customization, and the availability of valid & up to date learning content.
S4 [9]	2015	Rubric	Elementary Mathematics	Review	Quality content, feedback & scaffolding, interaction, and app adaptability circumstance.
S5 [10]	2015	Framework	Pre-schoolers	Review	Active involvement in learning tasks, deeply engaging learning content, meaningful experience, and socially interact.
S6 [11]	2015	Framework	Elementary	Experimental	Multimodal, curriculum-oriented content, effective navigation, and learner interaction.
S7 [12]	2016	Rubric	General	Review	navigation, ease of use, customization, aesthetics, screen design, information presentation, media integration, distractor less
S8 [13]	2017	framework	k-12 language	Review	Technology (navigation, interface, instruction, offline accessibility, gamification, and stability), pedagogy (quality of content, feedback, scaffolding, media, and customization), learner experience (interaction, sharing, and price), and language learning.
S9 [14]	2017	Rubric	preschool	Review	Contents (motivation, feedback, error correction, progress monitoring, unbiasedness), design (graphics, sound, menu, layout), functionality (learner-centred, option for configuration, control over instruction, autonomy), and technical quality (performance, reliability, interaction, advertisement).

Ok, et al [8] framed a three steps research process on educational apps Learning Disability (LD) evaluation rubric. It was designed with the help of 13 coherent appraisal criteria including clearly well-defined learning objectives, proper learning strategies, availability of multiple problem-based examples, practice options, learning feedback, error reporting strategies, maintaining learners progress, clear and easy navigation, motivation, multimedia stimuli, options for font style, learner's customization, and the availability of valid and up-to-date learning content. After incorporating these aforementioned criteria into the proposed rubric meanwhile, a sample of educational apps was tested on the same, and analyses revealed 13 evaluation parameters.

A survey-based approach was conducted by Cayton-Hodges et al. [9] targeting to know the design-based principles and strategies of mathematics tablet learning apps, especially from the Apple App Store. After careful analysis of literature findings especially focusing on digital tools, learning objects, and quality instructions. Based on such findings, they have proposed an app evaluation tool that scientifically covers and cater to four pertinent design principles as- quality content, feedback & scaffolding, interaction, and app adaptability circumstance. An article published by Hirsh-Pasek [10] targeted two major aims regarding science educational apps including an evidence based app development process and the designing comprehensive evaluation tools for them. So that we can put learning back into the learning apps. They argued a better education app should incorporate at least four educational pillars - active involvement in learning tasks, deeply engaging learning content, meaningful experience, and social interaction - while designing them.

On the same surge a one more research-based study conducted by Israelson [11] on the learning apps evaluation framework (The App Map) helps educationists to appraisal high-quality learning apps. The framework was proposed by them in two steps in which planned learning instruction came in the first step whereas the creation of an evaluation rubric was framed in the second step. Their proposed rubric was made of four app parameters including multimodal, curriculum-oriented content, effective navigation, and learner-centred approach. One of the highly impactful research projects was conducted by Cherner et al. [12] on the teacher resource app. It was the first study that assess the teacher learning apps based on a comprehensive evaluation rubric. In their evaluation tool they amalgamate three broad dimensions (efficiency, functionality, and design). Despite all our research problem targeting the design dimension only and it includes navigation, ease of use, customization, aesthetics, screen design, information presentation, media integration, and lack of distraction. Meanwhile, the biggest pitfall of this rubric is that it may not effectively evaluate the general learning app.

To evaluate language learning apps a widely accepted framework was developed by Rosell-Aguilar [13]. Their proposed framework contained four widespread dimensions for appraising language learning applications. Such set of evaluation criteria is technology (navigation, interface, instruction, offline accessibility, gamification, and stability), pedagogy (quality of content, feedback, scaffolding, media, and customization), learner experience, and language learning. Even though the proposed framework has been established as a milestone in the context of language learning but at the same time, it suffered from its validation process.

One of the most famous studies was proposed by Papadakis, Kalogiannakis & Zaranis [14] on preschool educational apps. They critically revealed the literature on such apps and summed up some crucial findings especially the issues with educational apps. In light of this, they have framed a coherent and workable rubric (REVEAC) with the help of four vital dimensions. A list of such dimensions is contents (motivation, feedback, error correction, progress monitoring, unbiasedness), design (graphics, sound, menu, layout), functionality, and technical quality. Although, this study is becoming the base for many studies but it is also suffering with some serious flaws including the issue of generalization (validated only on a very small sample) and the issue of inter reliability of REVEAC between the main and sub-criteria.

Even though there are a lot of useful studies on LA design, but we couldn't find a single one that focused on an object-oriented way of designing these apps. Therefore, the primary objective of our work is to provide an insightful blueprint for the object-oriented paradigm concerning current educational apps. We may be able to forecast better outcomes for future educational apps and widen our existing virtual teaching method beyond drill and practise by looking at how the same approach (object-based) has contributed to other study domains. Given these facts, it is urgently

necessary to develop an object-based design strategy that is comprehensive, logical, and capable of handling all of the necessary app ingredients (components).

3. CHALLENGES AHEAD

The literature variously refers to the issue of self-proclaimedness, app quality, poor design methodologies, lack of actual assessment instruments, and so on [3, 18, 19, 20, 21, 22, 23]. Here, we are going to incorporate a list of possible obstacles that app developers, teachers, students, app users, and their caretakers might face so that we can consider them when designing new and future educational apps. Figure 1 depicts a pictorial representation of the most frequently reported growing concerns confronting LAs today.
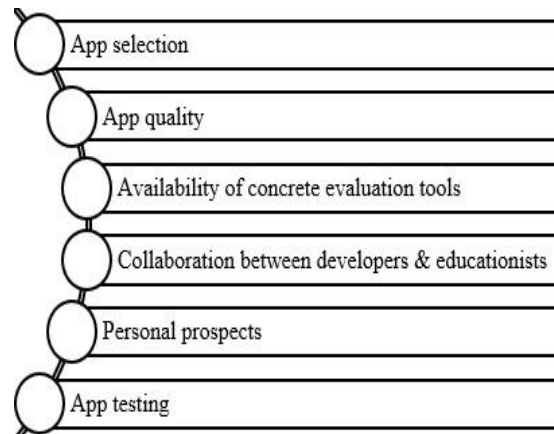

Figure 1. Emerging issues with LAs

Issues concerning app selection, app quality, availability of concrete evaluation tools, a collaboration between app developers and teaching experts, personal prospects, and last but not least issue of app testing are the most cited research challenges amongst the educational fraternity. No suitable app development strategies are specified by the government or other such higher authority, hence problems with app selection and quality are becoming a common and highly pertinent issues. This is the primary cause behind the abundance of (qualitatively inferior) apps in various marketplaces. Consequently, the correct selection of desired application(s) is not a simple task. Moreover, even if an app is chosen for learning purposes, it does not always contribute to the actual learning content. As a result, this problem calls into question the quality of existing learning apps [18, 19, 22, 23].

Research challenges also include the lack of comprehensive, coherent, and concrete evaluation methods and techniques for current educational apps. Anything not measurable cannot be controlled! Many such resources existed in the published literature, but the majority of them had serious flaws in terms of validation or usability. Researchers have recently uncovered an issue with the lack of collaboration between app creators and educators. As of late, this topic has received a lot of media coverage; why is that? Simply put, the vast majority of educational apps fail to meet the standards set by instructional designers because their designers have lacked necessary educational skills. For this reason, we (developers and education experts) must work together for better educational results [18, 23].

Meanwhile, when someone trying to find a list of "best apps" the majority of us see reviews or rating systems to use as a guide, it can be difficult to do so because such lists are often compiled based on the author's preferences rather than on scientific facts. This problem is known as the

issue of personal prospects. Last but not least, those who take a superficial approach to the problem of app testing, exhibit unscientific behaviour in terms of its (app) test or assessment. Most of the time, these tests aren't given in a scholarly setting, which results in poor testing (evaluation).

In light of recent scientific findings, it is becoming increasingly apparent that the majority of current design policies and other techniques for developing learning apps are ineffective due to the emergence of this newly and inexperienced virtual learning model as an innovative learning paradigm. Moreover, developer background knowledge, and numerous other such factors. Considering these factors, now can be a good time to suggest or propose a better app design strategy (approach) that can prove useful during the app's subsequent development. To systematically apply our research argument, we have first compiled a list of essential ingredients for learning app design (see the following section), and then provided a basic outline (blueprint) for a potential object-based approach to learning app design.

4. LEARNING APPS INGREDIENTS

We used a dual-track research strategy to identify potential key components (essential app ingredients) of successful educational app designs. As shown in Table 1, we began by reviewing the majority of the relevant literature on app design from a perspective that includes design ingredients (parameters). In the second stage, we analysed all of the included studies from S1 to S9 and some advanced literature also. In a conclusion, we offer the following list of what we believe to be such crucial ingredients (components):

- Clear Goal & Objectives [27]
- Pre-requisite Testing & Preparation
- Content Analysis, Classification & Learners Privacy
- Content Presentation [7, 25]
- Instructional & user interface [20]
- Feedback [13, 15, 21]
- Motivation and self-directedness [24]
- Remedial Contents
- Examples [13, 24]
- Formative Evaluation [26]
- Summative Evaluation [26]

As you can see in Figure 2, we compiled a list of eleven critical criteria that we believe, they are fundamental to every app's success. Importantly, most of them are approached by several researchers as an app criterion but no one could include all of them as a together for educational app design purposes. An object oriented design based approach is proposed, which has the potential to offer certain advantages over the current practise. This is the primary justification for employing such a app design strategy. It is now appropriate to clarify each key aspect for their basic understanding. The primary app ingredients inform us of the 'clear goal and objectives'. That is, a truly pedagogically sound app must include its learning objectives in easy and early phase [27].

Pre-requisite testing focuses on the validation of the designed LA target test, which implies if the selected app is working properly or not, whether students or teachers are properly log in throughout the app, and whether all designed learning modules are working as specified in the curriculum. One of the most important aspect of designing LA is their content analysis. Means, the structure of content design should be unique amongst face to face learning, e-Learning,

virtual learning (learning apps). Furthermore, there are various structural levels of content, including the curriculum level, course level, lesson level, and many more. So, app designer need to very cautious about the sound knowledge of learning contents and their apps target learners [28]. Among the many obstacles that students must overcome is the necessity of protecting their personal information. Almost all parents who use apps to teach their children have serious concerns about their children's privacy, according to the research, so developers of educational applications need to address this issue without taking any delay.

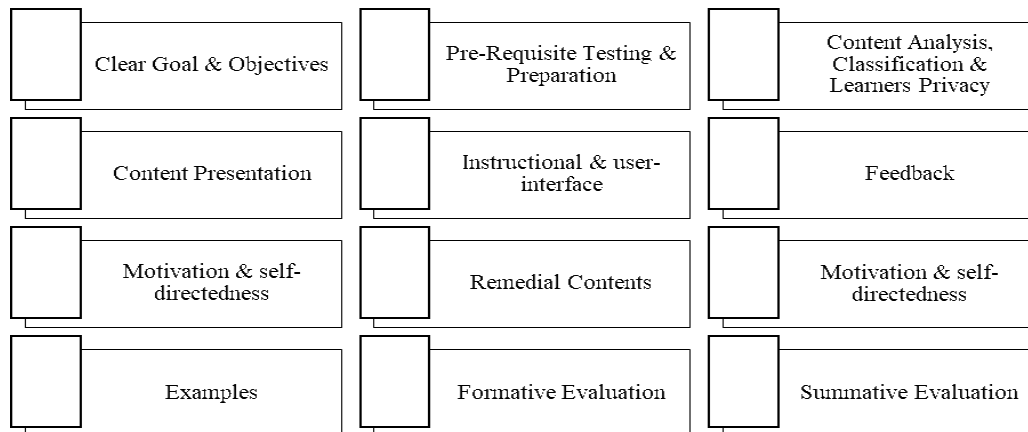| Clear Goal & Objectives	Pre-Requisite Testing & Preparation	Content Analysis, Classification & Learners Privacy
Content Presentation	Instructional & user-interface	Feedback
Motivation & self-directedness	Remedial Contents	Motivation & self-directedness
Examples	Formative Evaluation	Summative Evaluation

Figure 2. Essential LAs ingredients

Presentation strategies control the efficient distribution of content throughout the app. A visually perceptual approach get a learner more involved in the learning process than a boring learning presentation material. There are a number of content presentation method exist but incorporating appropriate one is still becoming a research gap [7, 25]. In the list of essential ingredients the next is 'instructional strategy and user interface'. The app instruction should be small in size, user-friendly, learners centred, and more than just series of moving videos. Parallelly, the user interface design should be ergonomically based [20]. An effective educational app should provide explanative instruction that should be more than just right or wrong dialog box feedback. It (feedback) can be multiple types including instructive, declarative, multimedia based, and so on. But, the selection of appropriate feedback throughout the app content is a highly challengeable task [13, 15, 21].

Motivation can be intrinsic or extrinsic, and it can also be of several forms. As a result, a successful app must include multiple motivator aspects (rewards, numbers, target points, and so on) but most importantly, when a learner requires them. Remedial information plays a significant part in learning and can be integrated utilising a technique known as reinforcement and completion. The final necessary component is evaluation, which can be both formative and summative. The most memorable aspects of this ingredient are where we should use them (formative, summative) and at what level (lesson level, unit level, and other level).

In light of scientific findings, people concerned about LAs, particularly their existing poor design tactics. Given these considerations, it may be an appropriate moment to recommend or propose a better app design strategy (approach) that will be valuable during the app's ongoing development process. Therefore, we suggest an 'insightful blueprint design' for the object-oriented paradigm with regards to contemporary educational applications. On the basis of how the same technique

(object-oriented) has impacted other study domains such as 'IEEE learning objects, object-oriented learning design approach [29, 30], we may be able to predict better outcomes for future educational apps and expand our present virtual teaching process beyond rote memorization learning.

5. BLUEPRINT OF OBJECT-ORIENTED DESIGN APPROACH

Experts generally highlight issues concerning effectiveness about current LAs. Out of them some major ones are: too much gamification, bad tutorials, poor progress tracking, no systematic repetition, absence of standards, and lack of a viable evaluation scheme. As a result, we observe the emergence of several design paradigms, having no or little theoretical bases. Even though businesses grow, and new tools and technology are developed, but there isn't a good app design strategy based on accepted didactics. Realizing this, we suggest a Pedagogic-Object-Oriented Approach to the design and development of LA based on an exhaustive literature review, a qualitative analysis of some learning apps (that is, what should be included in a genuine learning app), and other such observations. In the following section we are going to present a very basic idea (blueprint) about the 'Object-Oriented Design' approach in the context of same research problem.

As previously said, we have gathered a list of eleven essential apps ingredients and believed that an effective LA should contained all of them in their design process. Such viable ingredients are: clear goal & objectives, pre-requisite testing & preparation content analysis, classification & learners privacy, content presentation, instructional & user-interface, feedback, motivation & self-directedness, remedial contents examples, formative evaluation, and summative evaluation [7, 13, 15, 20, 21, 24, 25, 26, 27]. In the following section we are going to present an insightful blueprint in terms of LAs ingredients that follows an object-oriented design strategy.
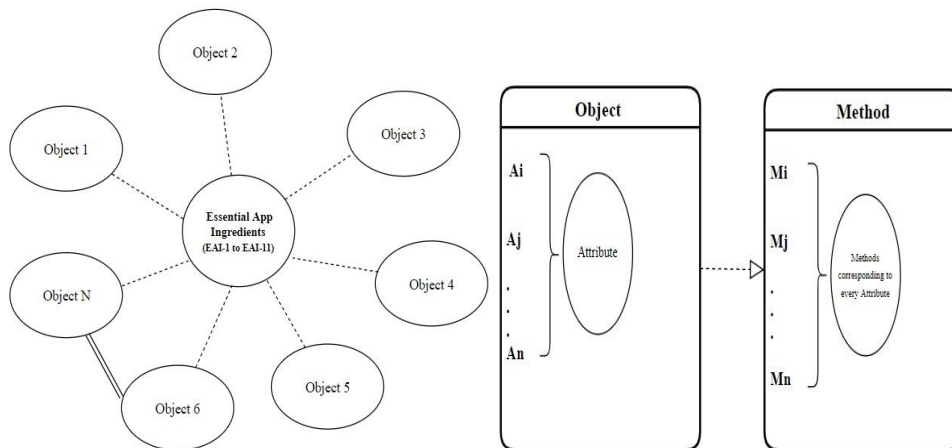

Figure 3. Blueprint of object-oriented design approach **Figure 4.** Implementation approach

The accompanying illustration depicts a preliminary iteration of an object-oriented design strategy for educational apps. The main idea behind the suggested method is to map each of the app's "ingredients" to a separate object (see Figure 3). Afterward, we use some methods and attributes to express each characteristic of the chosen ingredient in terms of their object as depicted in Figure 4. With this diagram, we want to show that an app ingredient can have "N" attributes (Ai to An) and the same "N" number of methods (Mi to Mn) we need to map each app's attributes. We've identified feedback as a crucial part of the app's design, thus we'll be making an object based on this specific element. Additionally, we need to consider feedback

from a pedagogical standpoint as the selected ingredient. As its possible attributes may be its types (positive, negative, immediate, and so on). Therefore, we need some pedagogically sound methods for each attributes. The same process will keep happening until every ingredient has a physical object and corresponding pedagogical method that goes with it. In our proposed blueprint we have selected EAI-1 (essential app ingredient-1) to EAI-11 (essential app ingredient-11) that is why we need a total of 11 different objects and their accompanying pedagogical methods for mapping that much ingredients (due to 1:1 mapping). By looking at how the same approach (object-based) has contributed to other research fields [29, 30], we may be able to predict better outcomes for future educational apps and broaden our current virtual teaching process beyond drill and practice learning.

In light of these scientific facts, it is imperative to establish an object oriented design strategy that is comprehensive, logical, and capable of handling all of the necessary apps ingredient. Despite the fact that the proposed technique is based on a fundamental concept, it will require some additional and rigorous effort to make it more applicable and effective in the present and future app development landscape. We believe it has the potential to be a paradigm-shifting idea for the future of educational software design.

6. CONCLUSION AND FUTURE WORK

An exasperating situation has arisen in the world of educational apps: while everyone wants to get the full benefits from these learning software. But, in terms of educational values, the educational community is at a loss as to how to best design them. The current design of LAs includes too much gamification, putting bad tutorials, poor progress tracking strategy, absence of systematic repetition ingredients, absence of standards, and many other such issues. In the light of this, we suggest a Pedagogic and Object Oriented approach based on eleven essential ingredients (clear goal & objectives, pre-requisite testing & preparation, content analysis, classification & learners privacy, content presentation, instructional & user interface, feedback, motivation and self-directedness, remedial contents, examples, formative evaluation, summative evaluation) to the design and development of LA, building on the idea of IEEE learning objects, object-oriented learning design approach and the success of the object-oriented paradigm in other field. In future our aim is to develop a comprehensive, logical and object-oriented design model that capable of handling all of the necessary app ingredients in a scientific way.

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