# A Model of Personalized Context-Aware E-learning Based on Psychological Experience

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***Abstract*—The use of context-aware approach in e-learning system has brought a new passion for users as an alternative to learning. It can provide personalized and adaptive learning patterns that can tailor to the needs, the circumstances and the behavior of users. Along with the continued development pervasive and ubiquitous computing, there are several studies related to this model. However, the existing models developed still focus on a wide variety of contexts, such as explicit contexts and context related to the physical environment of learning. Additionally, the developments of the current models by involving psychological condition of the learner taken into account are still limited. In fact, this condition can influence the learning engagement of learners. This research proposed a model of context aware e-learning that personalizing e-learning according to psychological state of the learners. The psychological experience is based on the theory of flow consisting of anxiety, boredom, and optimal condition measured naturally when users are interacting with e-learning. Furthermore, it becomes one of the strengths of this research. Psychological experiences are measured after the learner interacting with the e-learning. The data are obtained from learner behavior saved in the server log.**

***Index Terms*—Awareness, Context, Context-Aware; E-Learning; Flow Experience; Personalization.**

## I. INTRODUCTION

Equity and expansion of education access become a crucial issue and concern in determining the policy direction to improve quality of human resources. Some efforts have been done continually to provide quality education services to the community. It was conducted in line with the increasing needs and awareness of the importance of education. However, the rate of increasing the community's need for this educational service has not been linear with the rate of increasing in capacity, especially with the availability of classrooms, laboratories and other educational facilities and infrastructure. Particularly for developing countries with the high diversity of demographic and geographical, the appropriate breakthroughs are needed to solve this problem. The government has tried several programs in reducing this gap, one of them by implementing e-learning system [1].

E-learning has given an opportunity to educators and learners to conduct learning process through a virtual environment. Hence, E-learning continues to be developed to meet the needs of users regarding technology, models, and learning approaches. The development of e-learning is done in order to answer some fundamental issues in the implementation of existing e-learning [2]. The main issue related to the basic concept of learning itself, where learning is not just a transfer of knowledge. The second issue relates to its application, where it still needs time to change mindset for the people involved in this model of learning.

The shifting of learning paradigm from teacher learning center to student learning center has brought a new breakthrough in development e-learning model. This approach has encouraged the designing of e-learning model to pay more attention and emphasize to the needs of learners [3]. The e-learning is expected to provide more adaptive services in accordance with the situation and learning conditions. The situations in this context can be the condition of learners, the physical environment of learning, tools and the infrastructure used. By considering these aspects as learning context, the development of e-learning model can be directed by using model of context-aware computing approach.

Implementation of context-aware computing approach in e-learning will provide personalized and adaptive services tailoring the circumstances of the learners [4]. A context aware e-learning model is expected to reduce the fundamental issue of e-learning implementation. With this model, the e-learning is no longer seen as a system of one fit for all. Compared to current system, it becomes more personalized to the learner situation [5]. Several studies have been conducted in order to develop this context aware e-learning model. However, the developed models still use context derived from the physical environment of learning. The others context emphasis on computing contexts, including the device used, the quality of bandwidth and network infrastructure.

Although the current studies have provided adaptive services to the learners, still has not taken into account the personal condition of the learners. The situation related to the emotional state and the psychological condition of learners when interacting with e-learning. The context aware e-learning model that considering the psychological condition is limited. Therefore in this research will be proposed the conceptual and contextual model of context-aware e-learning. The conceptual model aims to provide a general approach of the context-aware e-learning model. This model will explain thoroughly a model of context-aware e-learning included the contexts used, context acquisitions, as well as the type of adaptation usually presented in the learning. Meanwhile, the contextual model based on the psychological condition, aims to improve the existing context-aware e-learning model. In this model, the psychological state of the learner is represented by flow theory [6]. Further explanations of the proposed model will be explained in the following sections.

## II. Literature Review

### A. Related Works on Context-Aware E-learning Model

Many studies related to the model of the personalized context aware e-learning have been done in order to improve e-learning model at this time. Besides using the terminology of the context-aware e-learning, several studies have also used the terms of recommender system, as well as personalized and adaptive context-aware e-learning. These studies focus on how to provide personalized learning using a variety of contexts. The model of the context-aware e-learning generally involve contexts related to the physical environment. The context of location, time, noise, lighting, temperature, and physical environments are more widely used to provide recommendations tailored to available physical sensors.

Research in the context-aware e-learning using RFID as a context sensor location has ever been undertaken in order to provide recommendations in the form of position detection of physical learning resources and closest learning peers. Recommendation of learning materials are used to support the exploration of knowledge related to natural plants in real environment. The system was implemented in a botanical museum [7]. The same action is also done using GPS sensors to seek the location of learning peer and learning resources nearby [8]. Shu-Lin Wang uses the context location with the RFID and personal learning profile for recommending appropriate learning objects [9]. In the context of other locations, Scott et al., add infrared sensors (IR), RFID and GPS on the model proposed by the recommendation materials, peer and learning tasks [10].

The context of times, locations, and activities are often used to provide recommendations for personalized services to users. Time is marked with a timestamp to a location or activity. Locations are associated with outdoor, indoor, public places, as well as private places. While activities may consist of rest, waking, working, walking and so on. Zhao et al., use the context of time, location, quality of the network and the type of device to provide adaptive learning content through a mobile learning [11]. In their research, Isabela et.al., use the context of time and location combined with the cultural background of a system to present recommendations and language learning material used [12].

Social context through feed back from social media tag has been used to generate recommendations for appropriate learning materials, peer learning, and tutors that suit users [13]. Based on this context, e-learning models are built and integrated with several social media applications to gain user input when interacting with social media via the feedback or tag of materials, and tutors.

User profile was ever used to connect learning material to profile of learners using matching context. Luo., et.al conducted research in a model of personalized e-learning with recommended learning materials for students using preference context [14]. In their study, the model provides learning materials relevant to learners from a set of available material. Nguyen and Phung use the context of this profile to present learning materials and pedagogical approaches appropriate for learners [15]. Meanwhile, the models and the characteristics of learners are also proposed to classify learners who have the same preferences to learning materials. Learners who have the same profile model get the same learning materials. Grouping is done by using the learning styles context [16].

Other studies propose a model of personalized context aware e-learning by creating a context grouping used in personalized e-learning. Shudana classifies contexts to adapt learning materials into three classifications, namely: situation context, domain context and context activity [17]. Situation context is related to hardware, software, network and location of learning. Domain context is related to topic and language used. Additionally, activity context is related to interests and goals of the learners. Gallego., et.al offer a model to acquire learning materials based on the social context (associated with the interest of students in courses offered), the location context (associated with the time and the geographical location of learners, country and language), as well as user context (related equipment / devices used by the user in accessing the learning materials) [18].

Grouping of the context-aware e-learning model is also done by Capuano., et.al to describe the model context aware e-learning using an approach of ontology. In their study, five classifications are proposed, namely educational context (associated with the state and level of education), course subject context (associated with the subject being undertaken), methodological context (related learning approaches: self-learning, synchronous, asynchronous, blended learning, formal learning), instructional context (associated with active learning, collaborative learning, game-based learning, inquiry learning), as well as the technological context (associated with the constraint of the device and the constraints of the network) [19].

Das divides the contexts of the parameters into four classifications, namely: profile context (related to the learner information profile, level of expertise, personality type), preference context (associated with learner intention, learner approach / preference, learner style), infrastructure context (associated with learner situation, network, and device) and learning context (related to the learning state and a more comprehensive level of learners) [20]. The same work is also done by Verbert., et.al who describe the results of exploration and survey of e-learning context aware. Research suggests a wide variety of contexts used in e-learning, such as computing context (network, hardware, software), place, time, physical condition, learning material, activity, user, and social relations [21].

Other studies related to the grouping of the contexts in the model are focused on the users and the user interaction with e-learning. Users are represented by internal and external profile, while the interaction with the e-learning is represented by the user interaction with the application/tutor and other users. While the recommendation is associated with learning object profile, service profile and tutor profile.

### B. Related Works on Flow Theory in Learning

The involvement variables of the Technology Acceptance Model (TAM) and theory of flow were developed by Liu and Yuan in the online e-learning users [22]. This study aimed at looking at the user's acceptance behavior that was integrated into the web-based streaming e-learning. This study used a text-audio learning materials, audio-video, and text-audio-video. Attitude, perceived usefulness, and perceived ease of use were used in variable TAM, whereas concentration was used in variable flow. The study showed that the consideration of appropriate learning materials presentation have positive relation to concentration, so that the needs of learners should be carefully emphased when designing e-learning.

Another study has applied flow experience into a face to face learning environment. This study focuses on the relationship of flow experience with a multimodal learning environment. The aim of study is to find out more about the flow experience of learners in the problem-based learning by involving multimodal learning environment. Another aim is to increase multimodal learning environment to understand the environment that can enhance the flow experience of learners. The multi-modal learning environment in this study was conducted in the classroom by involving a wide range of sources of learning materials.

P.I. Santosa proposes a conceptual model of flow theory in utilizing e-learning [23]. This study uses two variables subjective challenge and skill. Flow experience is seen as correspondences between challenge and skill. In this study, the challenge is represented as lectures and web navigation, while skill is represented by the web prior knowledge and experience. Furthermore, the symptoms are represented by the perceived flow of control and concentration. In this study, symptoms of flow affects are proposed to influence the performance of learners. This study reveals that the design of e-learning should motivate students to stay focused on the materials presented so that there is a challenge for how to design e-learning to accommodate the characteristics of different students.

A similar work has ever been applied in viewing student engagement in the online tutorial. In this study, flow is represented by the size of the web page (challenge) and prior knowledge (skills). Both of these variables are positively correlated with the ease of navigation related to the attitude that is related to student engagement. This study also involves two other variables such as the perceived benefit that positive things are gained by students during using e-learning, while the perceived costs are the things that give negative impacts on the learner when interacting with e- learning [24]. The study concluded that regarding technology use in online learning, the student engagement is influenced by various factors related to the design of online learning.

## III. THEORETICAL BACKGROUND

### *A. Context-Aware Computing*

The concept of context-aware was first proposed by Shilit and Theimer in 1994. According to their context is the location of use, a collection of people, close objects, and the change of the objects over time [25]. According to Dey, Context is any information that could be used in order to characterize the situation in an entity. The entity can be either a person or object that is relevant to user interaction with the application itself [26].

Context awareness is the use of contexts to provide information and task-relevant interactive services between users and the elements in the surrounding environment. A system is context-aware if the system uses contexts to provide information and services relevant to users, where relevancy depends on the user's activities [27].

### *B. Context-Aware E-learning*

In the previous section, it has been described the context aware based applications. In the case of e-learning, context is defined as the current situation with regard to the learning activity. A context in e-learning may be prior knowledge, learning style, learning speed, current activities, learning objectives, time availability, location, and other interest [28]. It is used for personalization, recommendations and adaptation of learning materials in accordance with the interests, circumstances, environment, and learning style of the user. Therefore, in e-learning environment, a context can be seen from a user perspective by considering various factors that influence learning style. In the context-based adaptive learning system, it has basically three important stages that must be performed, namely acquisition context, context modeling and adaptation context.

### *C. Personalized E-learning*

Personalization concept is the process of changing or adding something to the object so that it matches the needs of an individual. In the context of the e-learning environment, personalization has become a very important topic because the learning process is no longer done the same for all individuals who have ways, preferences, and interests. Therefore, it becomes a very important thing if an e-learning system can provide materials, paths and learning approaches according to each student's needs and expectation.

Personalization of e-learning is defined as a learning approach that facilitates and supports individual learning where each user has a path and learning services according to his/her needs. In general, the process of adaptation in the personalization of e-learning can be done by three processes, namely: Selection, Sequencing, and Presentation [29]. Selection regard to the selection of learning materials in accordance with the levels. Sequencing is concerned with how the learning material or learning object which is produced from a selection is prepared in accordance with the user's individual learning paths and pedagogical approaches were undertaken. Meanwhile, the presentation is concerned with how learning materials are presented in various forms of media, size, and others.

Adaptation to the personalization of e-learning is based on components of the personalization that include parameters, conditions, and contexts that describe the characteristics of learners. These characteristics are obtained through data classification of learners from a series of surveys that are entered to the e-learning system as well as from data obtained from the interaction of learners with e-learning system. Examples of parameters that can be used as a context in the personalization of e-learning can be seen in the Table 1.

The contexts will determine about a type of personalization, as much as possible to match with the given contextual information. Based on Table 1, there are three types of contexts: personal, abstraction, and situation [20]. These type of contexts are supported by several parameters that are describing the contexts.

### *D. Flow Theory*

Flow theory was first introduced by Mihaly Csikszentmihalyi who used the terms of flow to represent the optimal experience of someone to focus on his/her engagement in an activity [6]. Some of the elements and characteristics of flow conditions indicate improvement and motivation in learning. Wigan., et.al classifies the elements of the flow from several previous studies into flow antecedents, flow experience, and consequences flow as shown in Table 2 [30]. While Hoffman and Novak summarize into flow antecedents, flow experiences, and flow consequences [31].

Table 1
Type of contexts

| Context | Parameter |
|---|---|
| Personal | |
| Personal information | Name, ID, Date of birth, address, gender, email, phone number, technologies were known, knowledge level, OS experience, internet usage |
| Personality type | Extrovert, sensory, thinkers, judgers |
| Level of expertise | Beginner, practitioner, expert |
| Abstraction | |
| Learner preference | Conceptual, example-oriented, case-study, simulation, demonstration |
| Learner intention | Research, survey or overview, quick reference, basic introduction, project, assignment, seminar |
| Learning style | Video, audio, text, animation, slides |
| Situation | |
| Learner situation | Private, public, driving |
| Network | Wired, wireless |
| Device | Mobile, PDA, laptop, PC |
| Quality of learning service | Functional requirements, non-functional requirements |

Table 2
Components of flow

| Flow Antecedents | Flow Experience | Flow Effects |
|---|---|---|
| • Perceptions of clear goals<br>• Immediate feedback<br>• Matched skills and challenges | • The merger of action and awareness<br>• Concentration<br>• A sense of potential control. | • Loss of self-consciousness<br>• Time distortion<br>• Experience which becomes autotelic. |

Although the flow is built by several complex variables, the skill and challenge are the two most important variables [32]. Therefore, the flow experience is often depicted with these two variables are involved. In general, the flow theory puts forward three conditions, namely the optimal conditions (flow state), anxiety and boredom. The optimal condition is reached if the skills are in line with the given challenge, nervous conditions occur if skills are low and challenges are high, while the condition of boredom occurs if skills are high while challenges are low.

## IV. The Proposed Model

### A. Model Development

Related studies as discussed earlier have given an overview of the context and recommendation (awareness) used in the model of context-aware e-learning. However, the models that have been presented are still largely associated with the classification of contexts with the various recommendations presented. The available models do not fully display context and recommendations in a generic way, particularly in the context-aware e-learning. It includes models that have not yet covered the process that should be present as a process of the acquisition context and also adaptation process, especially in the process of evaluation and measurement of e-learning model.

The studies that have been conducted suggest that context is multi-dimensional. In the model of context-aware e-learning, it can be involved one or a combination of some contexts. Similarly, with the recommendations presented, they may involve one or a combination of several recommendations. Everything is tailored to the needs, situation, goals and learning scenarios conducted. The representation contexts as presented in previous studies can be summarized in Figure 1.

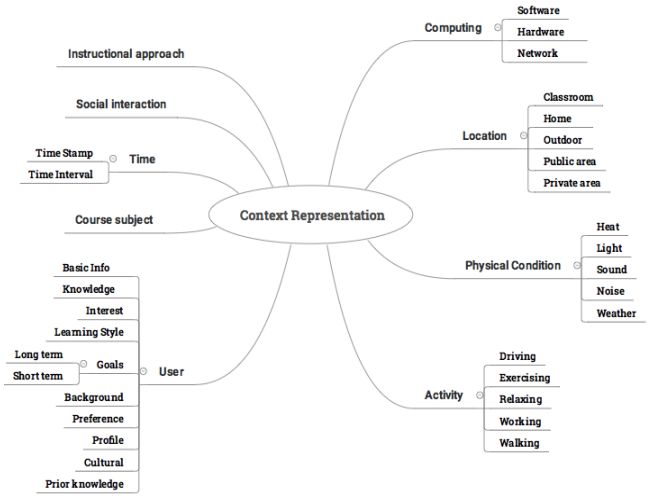


Figure 1: Context representation

The contexts used in the studies that have been conducted generally remained static in accordance with the information entered. If there is any change in conditions of the context, it is caused more by learning environments and physical devices (external users). The contexts showing behavioral, emotional state, motivation, engagement and user interest while interacting with e-learning are still limited. On the other hand, information about psychological condition indicated by the user behavior in e-learning is a very important aspect. Involving contexts in e-learning can support supervision of user's e-learning from the affective point of view. These contexts can not be obtained implicitly or explicitly, but through a process of inference through data patterns as a result of user interaction with e-learning. Based on this information, the context acquisition process can be classified in three ways, as shown in Figure 2.


Figure 2: Context acquisition

The representation of context on the model of the context-aware e-learning determines the kinds of recommendations (awareness) generated. The recommendations presented in studies that have been previously conducted are mostly related to the selection of teaching and learning materials. However, recommended places and time of the study, the location of the source of learning, and learning peer have always been the focus, especially in mobile learning models. These recommendations are generated based on the adaptation of one or a combination of several contexts identified. As well as the context, the models that have been done do not represent the awareness that is generic from a model of e-learning. In general, the recommendations (representation awareness) are shown in Figure 3.

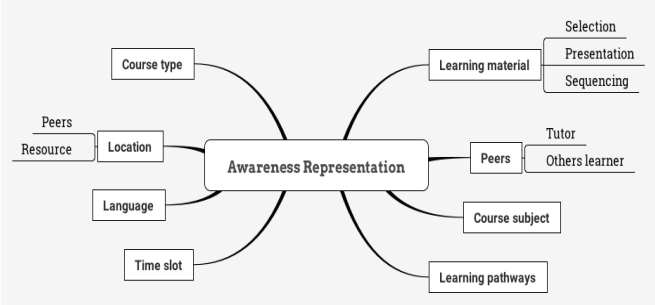


Figure 3: Awareness representation

*B. The Proposed of Conceptual Model*

The main components that must be completed in the proposed model of context-aware e-learning are the presence of three main dimensions, namely user, context, and awareness. The user is primarily concerned with the learner involved directly in the model built. The model model is constructed by considering existing the e-learning context aware model. In the previous section, it is classified into more generic into the internal learner context, external learner context, learner interaction, and learning context. While the dimensions of awareness include adaptation related to learning materials and related to the learning activity. Based on this framework, one user can associate with many contexts and many types of adaptation. Or, many users can associate with one context and one or many types of adaptation. The situation depended on the needs of the model. Furthermore, another important component in building the proposed model is the process of the acquisition of context and process of adaptation awareness. The conceptual model of the e-learning context aware in this study can be seen in Figure 4.

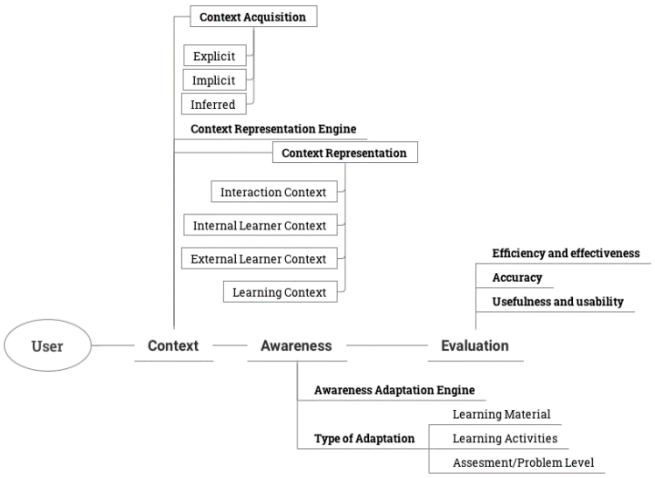


Figure 4: Conceptual model context aware e-learning

Users referred to in the conceptual model are learners who received the e-learning services. Users such as tutors, academic managers, and system administrators are categorized as part of their e-learning system with the main role as facilitators of services to the learners. Other dimensions on this model can be figured out as follows:

*a. Context*

In a context aware application, in general, context is defined as all kinds of information that can be used to characterize / illustrate the situation of an entity. An entity can be a person, place, time, or another object that is considered relevant to the interaction between users and applications. In the model of the personalization of the e-learning context aware, this context is divided into four as an internal learner context, external context learner, learning context and interaction context. Internal learner context is associated with the user context includes profiles, background, culture, language, preferences, activities, learning style, and other psychological conditions. External learner context is related to the physical environment of learning such as brightness, noise, the device being used, network, location, time and other physical environmental conditions. Learning context is related to the learning instruction, pedagogy, and course type. Additionally, the interaction context is primarily concerned with social relations as well as user interaction with other systems.

*b. Acquisition and Adaptation Engine*

Acquisition / Adaptation engine for e-learning can be described as a unit process that requires input from the learner contextual information and makes a recommendation / awareness to the learner [33]. Input is obtained through the acquisition context as presented in Figure 2. From some of the literature review undertaken, the approaches can be identified into two: acquisition / adaptation engine that is implemented on a model of the personalized context-aware e-learning, namely: (i) acquisition / adaptation rules; (ii) acquisition / adaptation algorithm.

Through the approach of acquisition / adaptation rules, acquisition and representation context, recommendation and personalization are obtained through a state sentence structure (if / else / then statements). While the approach to acquisition / adaptation algorithm, acquisition and representation context, recommendation and personalization are done by applying various types of algorithms, such as heuristic algorithms, intelligent approaches, matching algorithm, artificial algorithm, similarity algorithms, decision-based algorithms, and methods related to machine learning.

*c. Awareness Representation/Type of Adaptation*

Broadly speaking there are two categories for the forms of representation awareness (adaptations) of the model of the personalization of the context-aware e-learning, which is associated with the adaptation of learning materials, and the second is related to the adaptation of the learning activity [34].

Adaptation is related to learning material consisting of three forms, namely: (i) selection; (ii) presentation; (Iii) navigation and sequencing. Adaptation by selection with regard to the selection of instructional materials / problem right based on selection criteria derived from the learner contextual information. Adaptation based presentation is how to show learning material based on the device being used, the location and time, as well as the format of the material available. While adaptation related to navigation and sequencing, recommend structuring the possibility of navigation and sequencing of different learning materials that are connected to one another to create personalized learning paths.

Adaptation related to the learning activity consists of four forms, namely: (i) general adaptations, this adaptation automatically provides adaptive learning activities based on

the criteria of context; (ii) feed back and support (scaffolding), this adaptation is generally recommended time and appropriate learning activities; (iii) navigation to locations, this adaptation is primarily concerned with the event, and learning resources; (iv) communication and interaction, this adaptation provides recommendations with regard to collaborative learning activities such as peer information, tutors, etc.

*d. Evaluation the Model*

Evaluation of the proposed model can be conducted in parts and all parts of the model. Evaluation of part of the model especially related to accuracy value of context identification or accuracy during type of adaptation. The accuracy can be conducted using prediction results compared to questionnaire results. If the model implements the machine learning methods, the accuracy can be reached through confusion matrix. Meanwhile, the usefulness, effectiveness, and another usability can be done for the whole model after being implemented in the real situation. One of the evaluation and measurement tools for the whole system can use the user experience questionnaire [35].

### *C. The Proposed of Contextual Model Based on Psychological Experience*

A contextual model of the context-aware e-learning in this study is based on the psychological experience of learning. It is based on state of the art of previous studies showing that the context-context related to user shows the variation and the dimensions are diverse. While the contexts related to the physical environment, location, time, software and hardware, as well as common human activities do not show a lot of variations. Therefore, the dynamics and variations user context are high enough. The addition of the psychological context in the proposed model is very important and supports the affective side of learning. On the other hand, this state shows a very significant aspect of learning. The learning process with attention to psychological conditions can affect the learner's interest and engagement in the learning process.

Psychological condition identified as a context in this study is represented based on the theory of flow. Someone on the optimal condition (flow state) is at a top immersion so that there is no space for other thoughts or distractions.

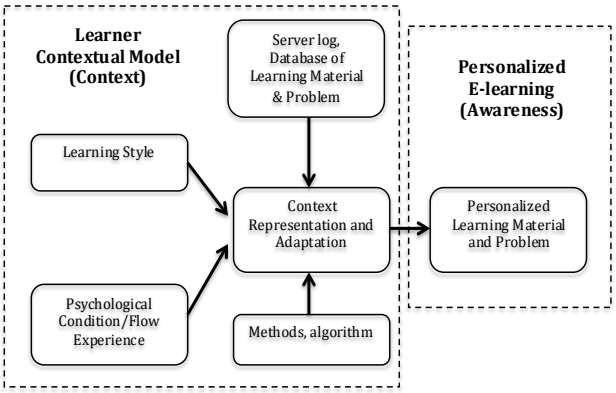


Figure 5: Contextual model context aware e-learning

Although the flow is built by several complex variables, the skill and challenge are the two most important variables. Therefore, the flow experience is often depicted with these two variables involved. Therefore, the balance of skill and challenge/problem is the focus on the process of adaptation / personalization models. In this contextual model, the skill is supported by the personalization of learning material based on learning style context, while personalization challenge/problem is based on the experience of the flow context. The contextual model can be seen in Figure 5.

The contextual model processes the acquisition of the context by inference. Learning style and flow experience are inferences based on learner behavior when interacting with e-learning. The context is acquired based on attributes / parameters of log data on the server. Furthermore, these attributes are extracted, represented into context using the acquisition engine. For each learner with the identified context will be given in the form of personalized learning and problem. This process is performed by the adaptation of engine on the model. As an illustration, the context acquisition and the type of adaptation processes can be seen in the Figure 6.

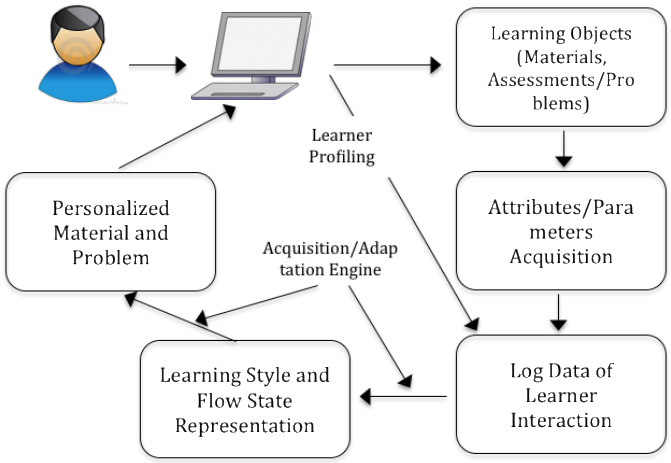


Figure 6: Acquisition and adaptation process

In term of psychological experience, type of adaptation of the contextual model, aims to monitor and control that the skill and challenge are in balanced condition (flow) as can be shown in Figure 7. Therefore, this contextual model provides selected learning material according to the learner style and selected challenge according to the flow state.

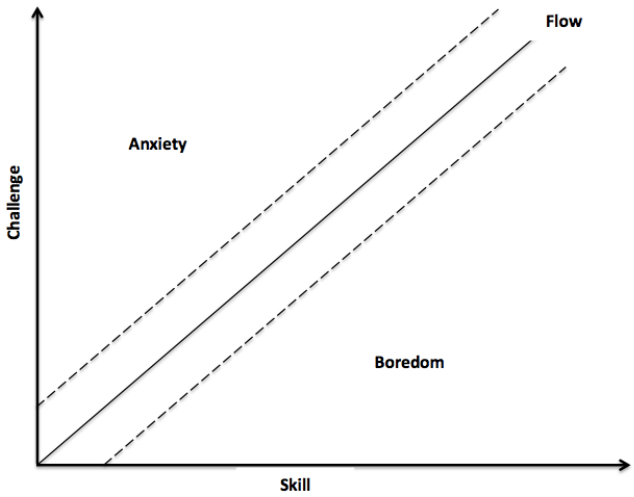


Figure 7: Flow states

## V. CONCLUSION

The model of the context-aware e-learning based on psychological experiences has been presented in this study. In general, this model is developed based on the conceptual and contextual model. The conceptual model provides the framework and processes that can be used in applying the model of the context-aware e-learning. Meanwhile, the contextual model is based on the psychological experience based on the learning style and flow experience context. The combination of these two contexts supports the creation of a balance of skill and challenge for achieving optimal learning. Therefore, this research is expected to contribute as the guideline for the development and improvement of the model of the context-aware e-learning.

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