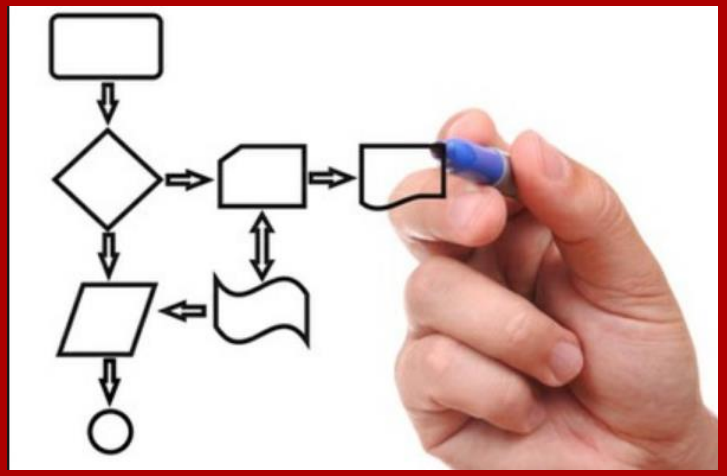
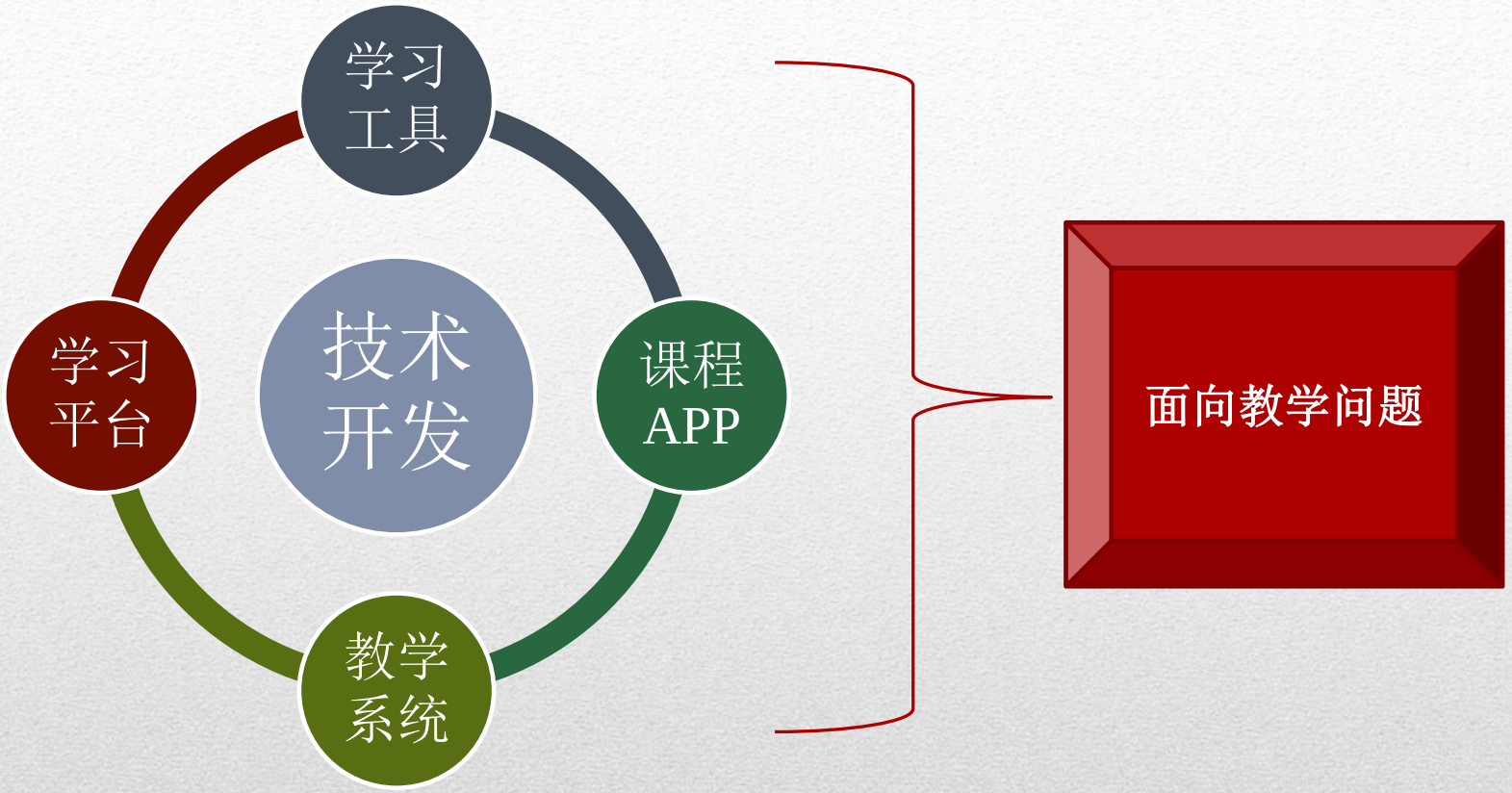


技术开发法

吴鹏飞

2015.2



技术开发法（教学软件工具）

听课大师

课程APP

学习元平台

技术开发法（软件工程）

技术开发法：利用软件开发手段解决教学中存在的问题。

Development of Activity Generation and Behavior Observation Systems for Distance Learning

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SCI：Computer Application in Engineer Education

技术开发法Paper实例

远程学习和**e-learning**常利用监控系统帮助教师评价学生学习状态。该研究也开发了一个活动生成和行为观测系统实现学习活动评价。定义了学习活动模型、方便教师管理学习活动、开发了活动识别器帮助教师实时监控学生学习行为并提供指导。通过实验方式验证了该系统的可用性和有效性，结果显示该系统能够提高学生学习成绩。

ABSTRACT: Distance learning and e-learning are popular and widely used technology in today's teaching environment; monitoring systems allow teachers to assess the learning state of their students. This study proposes a development of activity generation and behavior observation systems that allows teachers to assess the learning activities of their students. We use the concept of deterministic finite automaton to define learning activities. In the proposed system, teachers only need to click the drop-down list items to manage learning activities. The proposed system also generates an activity recognizer after defining the activity. The activity recognizer can parse student-learning logs allowing teachers to get the real-time learning activities of students. When students are in abnormal learning states, teachers can immediately provide them with active guidance. The experiments in this study demonstrate the feasibility and effectiveness of the proposed system. Experimental results show that students received higher grades and exhibited less abnormal learning with the proposed monitoring system. These results demonstrate that the proposed system provides teachers with a convenient interface for assisting their students. The proposed monitoring system improves the learning outcomes of students. Comput Appl Eng Educ 22:52–62, 2014; View this article online at wileyonlinelibrary.com/journal/cae; DOI 10.1002/cae.20528

Keywords: distance learning; monitoring system; active guiding; learning activity; learning portfolio

远程学习；监控系统；动态指导；学习活动；学习档案袋

核心研究问题

- 远程学习师生学习交互在学习过程中很重要。e-learning学习系统提供learning portfolio学习档案袋记录了学生的学习活动。然而，存在如下问题：
- （1）analyze learning portfolios takes more time and effort.
- （2）embarrassed to ask questions in front of other students. Teachers need to know if students are experiencing any problems during the learning process.

A real-time and adaptive learning activity monitoring System allow teachers to counsel their students efficiently.

This study designs and implements an activity generation and behavior observation system. The proposed system uses the real-time learning events of students to recognize their learning activities. The teacher can then monitor these real-time learning from the learning platform. The proposed system supports an interface for teachers to manage the activities that they want to monitor in the course. After defining or modifying the activities, the system generates an activity recognizer. Using the proposed activity recognizers, teachers can determine students' learning activities and actively provide real-time guidance when students experience abnormal learning states.

研究方法-技术开发法

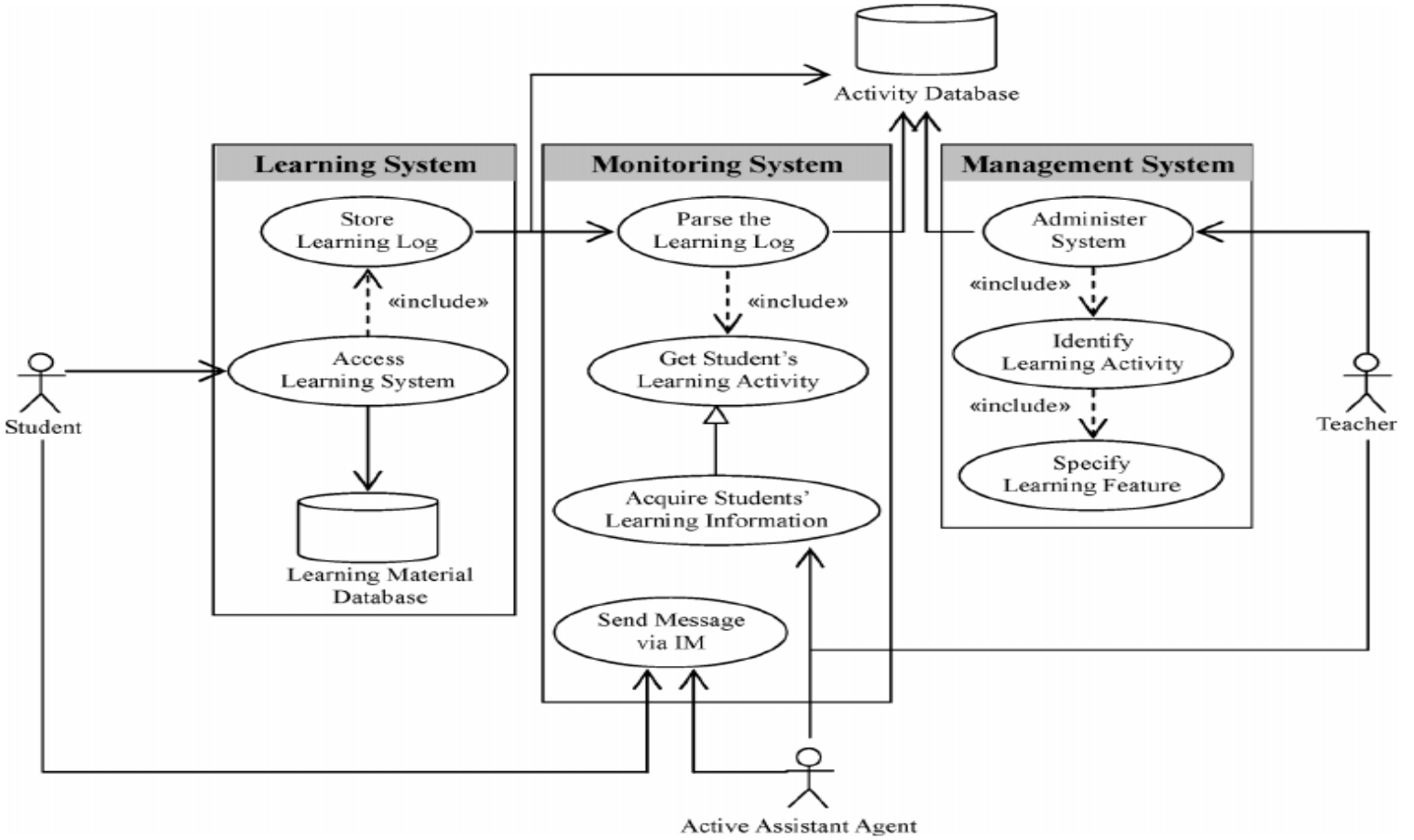


Figure 1 The use case of the proposed system.

技术开发过程-系统用例图

- 用例图主要用来描述“用户、需求、系统功能单元”之间的关系。它展示了一个外部用户能够观察到的系统功能模型图。帮助开发团队以一种可视化的方式理解系统的功能需求。
- 用例就是外部可见的系统功能，对系统提供的服务进行描述，用椭圆表示。
- 用例图所包含的元素：**参与者(Actor)、用例(Use Case)、子系统(Subsystem)、关系、项目(Artifact)、注释(Comment)。**

技术开发过程-系统用例图

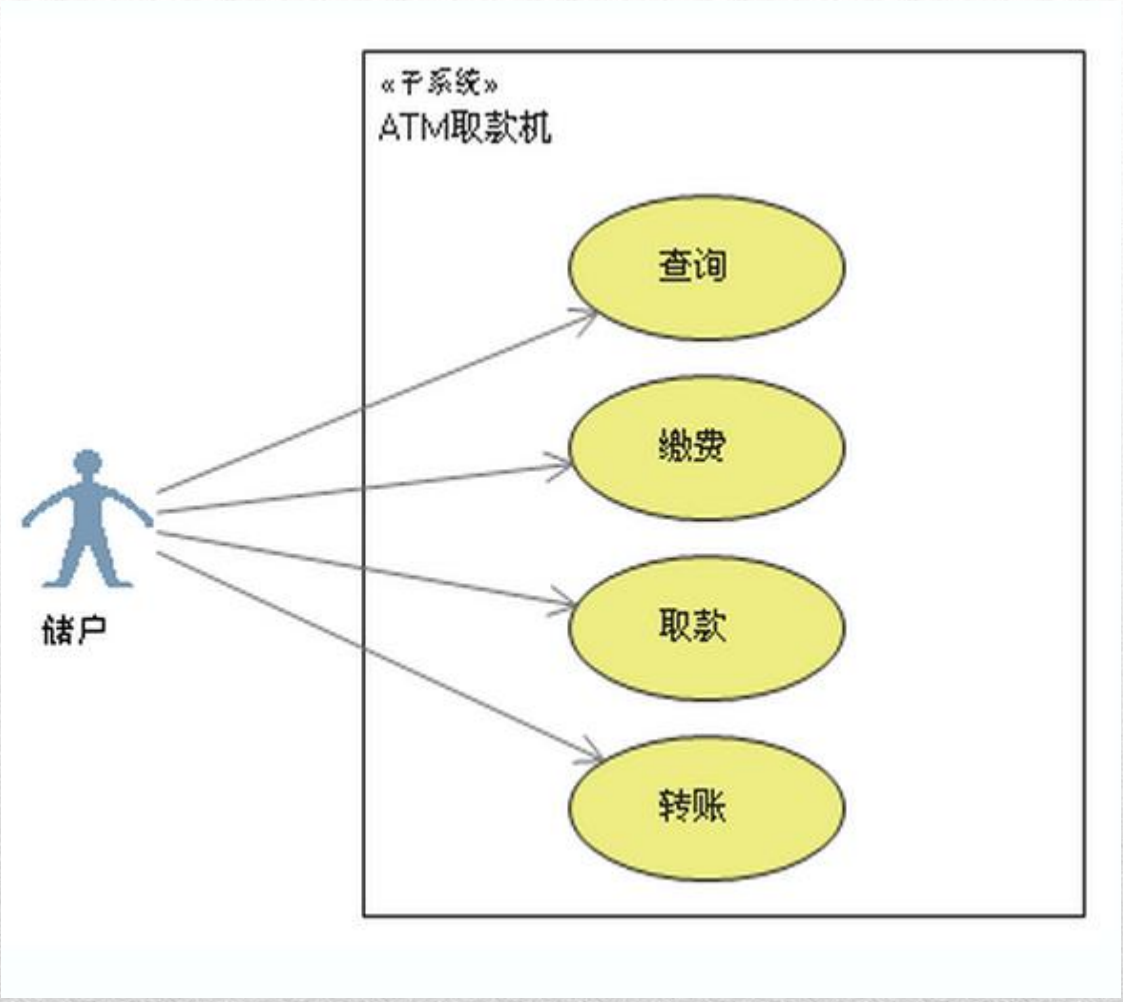
技术开发过程-系统用例图

- **参与者(Actor)：**表示与您的应用程序或系统进行交互的用户、组织或外部系统，用一个小人表示。

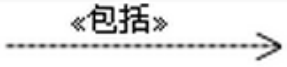
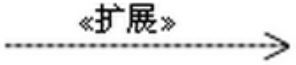
- **用例(Use Case)：**用例就是外部可见的系统功能，对系统提供的服务进行描述。

技术开发过程-系统用例图

- **子系统:**用来展示系统的一部分功能，这部分功能联系紧密。



- **关系：**用例图中涉及的关系有关联、泛化、包含、扩展4种基本关系。

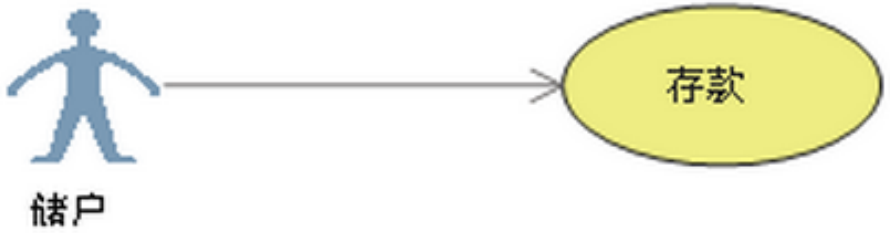
关系类型	说明	表示符号
关联	参与者与用例间的关系	
泛化	参与者之间或用例之间的关系	
包含	用例之间的关系	
扩展	用例之间的关系	

技术开发过程-系统用例图

a. 关联(Association)

表示参与者与用例之间的通信，任何一方都可发送或接受消息。

【箭头指向】：指向消息接收方

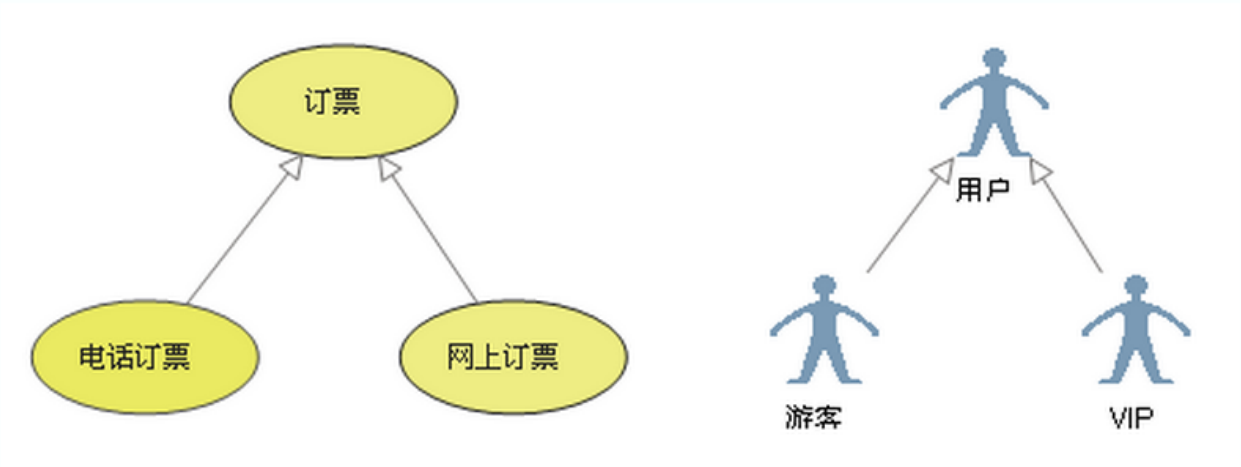


技术开发过程-系统用例图

b. 泛化(Inheritance)

就是通常理解的继承关系，子用例和父用例相似，但表现出更特别的行为；子用例将继承父用例的所有结构、行为和关系。子用例可以使用父用例的一段行为，也可以重载它。父用例通常是抽象的。

【箭头指向】：指向父用例

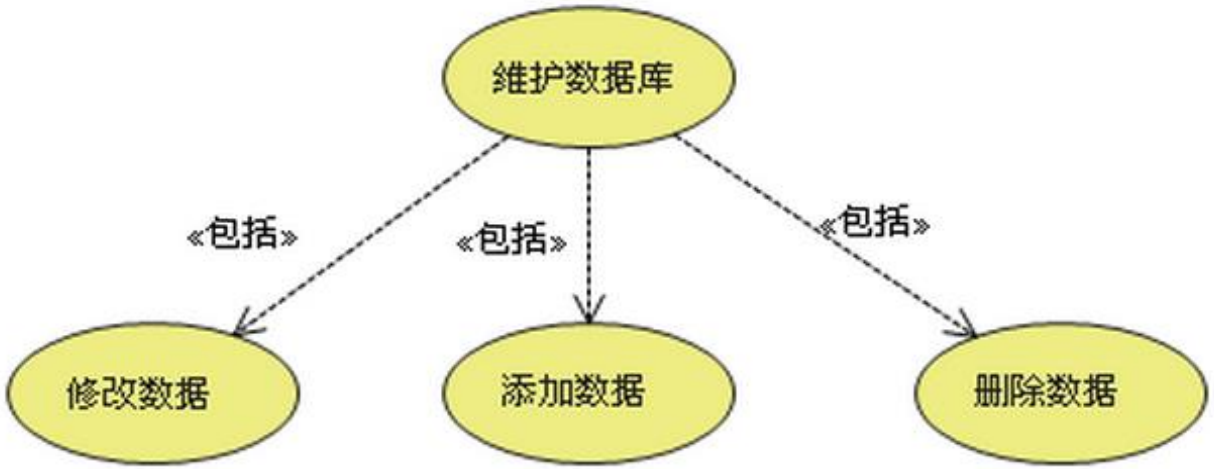


技术开发过程-系统用例图

c. 包含(Include)

包含关系用来把一个较复杂用例所表示的功能分解成较小的步骤。

【箭头指向】：指向分解出来的功能用例

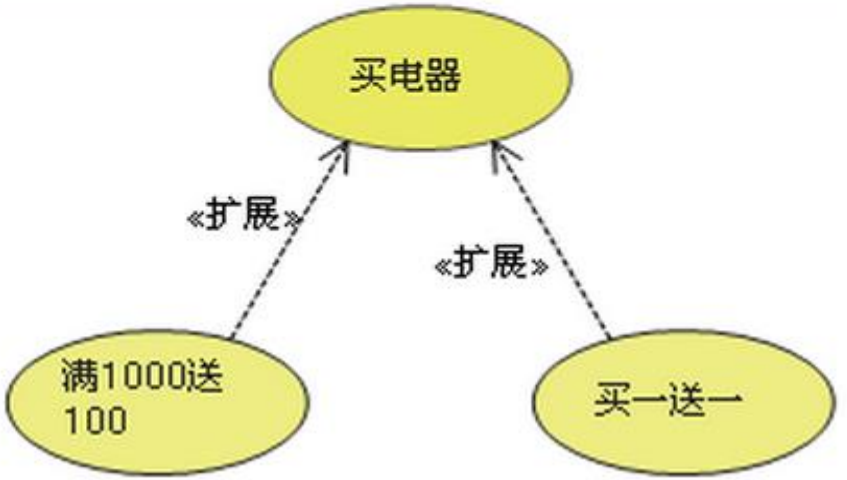


技术开发过程-系统用例图

d. 扩展(Extend)

扩展关系是指用例功能的延伸，相当于为基础用例提供一个附加功能。

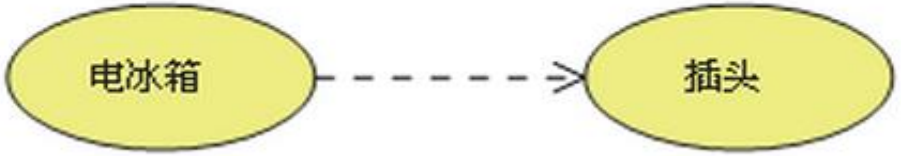
【箭头指向】：指向基础用例



技术开发过程-系统用例图

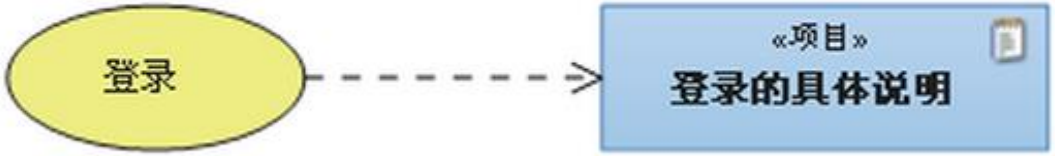
- **e. 依赖(Dependency)**

【箭头指向】：指向被依赖项

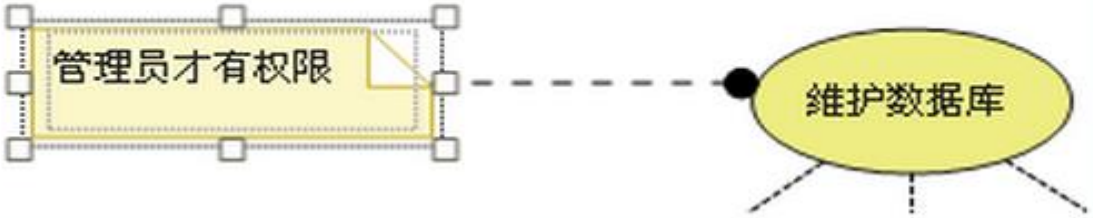


技术开发过程-系统用例图

用依赖关系把某个用例依赖到项目上：

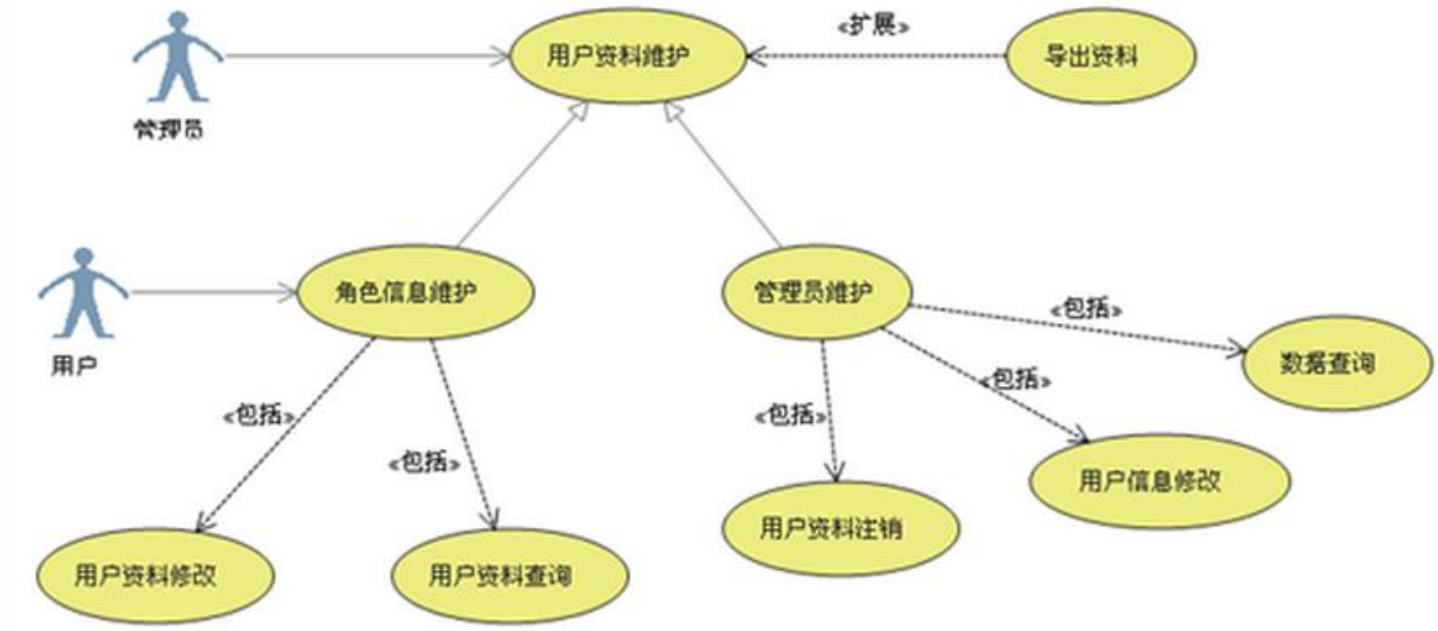


注释(Comment)



技术开发过程-系统用例图

一个用例图示例：



技术开发过程-系统用例图

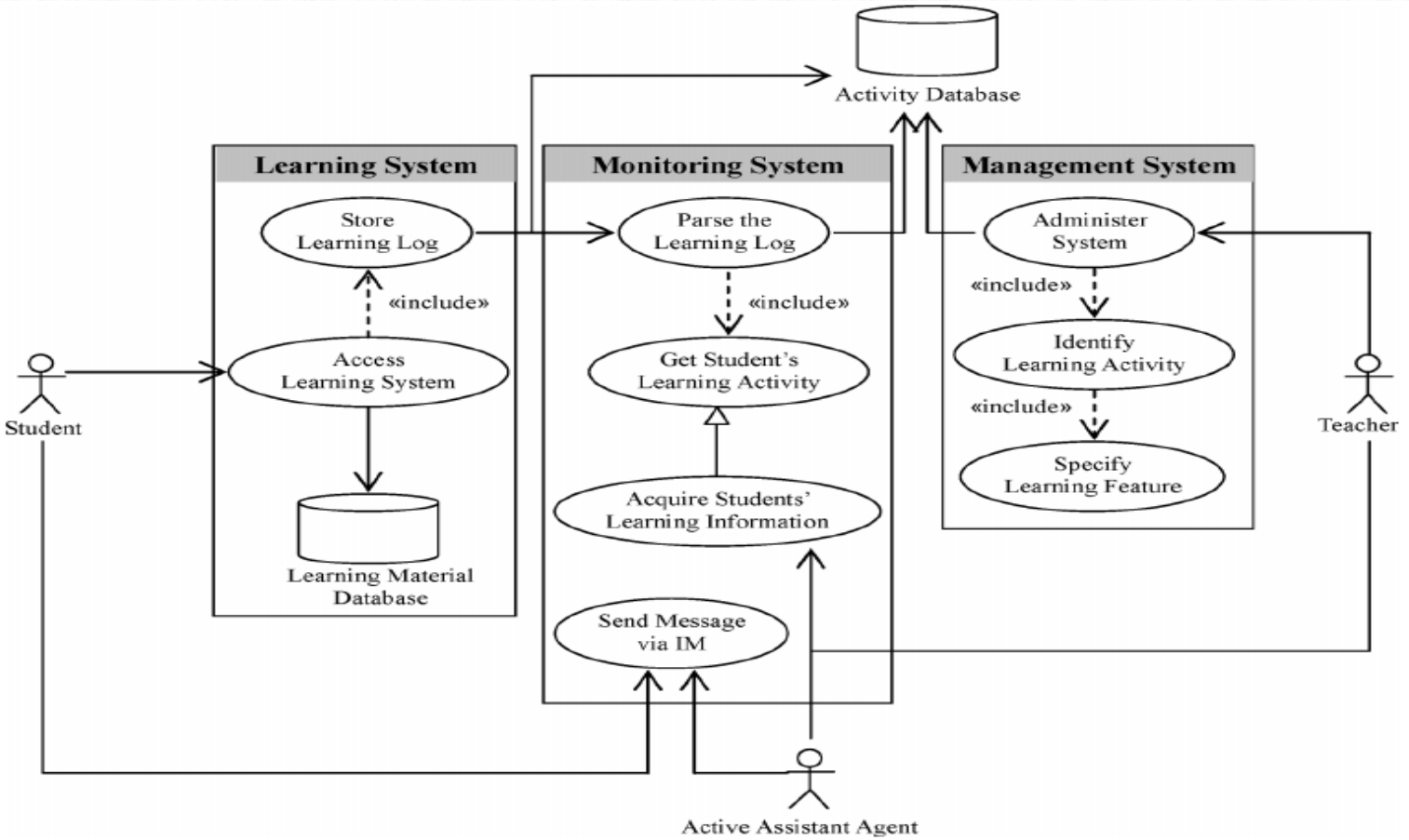


Figure 1 The use case of the proposed system.

技术开发过程-系统用例图

Definition 1: The learning activity is a five-tuple, $L_A = (S, A, I, F, P)$, where

(1) $S = \{S_1, S_2, \ldots, S_i\}$ is a finite set of activity states. Each learning activity has a set of states that is dependent on the learning environment. This set includes all the learning activity states.

(2) $A = \{A_1, A_2, \ldots, A_j\}$ is a finite set of actions for the learning activity. The normal actions for the activity are used to transform activity states. To complete the conversion from initial state(s) to final state(s), a series of actions are accomplished and the learning activity is performed. The proposed learning system detects and records all of the actions and events.

(3) $I \subseteq S$ is the set of initial states of the activity. A learning activity could have one or more initial states, and the activity should begin with one of these initial states. Thus, all the states that can potentially trigger the learning activity will be in the set.

(4) $F \subseteq S$ is the set of final activity states. These final states are necessary to determine if an activity is accomplished. Until the initial state transforms into the final state, the activity is not accomplished. Therefore, a teacher can identify which students have accomplished

学习活动的五元组模型定义：

S表示学习活动状态集；

A表示学习行动集；

I表示学习活动初始状态；

F表示学习活动最终状态；

P表示学习活动状态间的关系集。

技术开发过程-模型定义

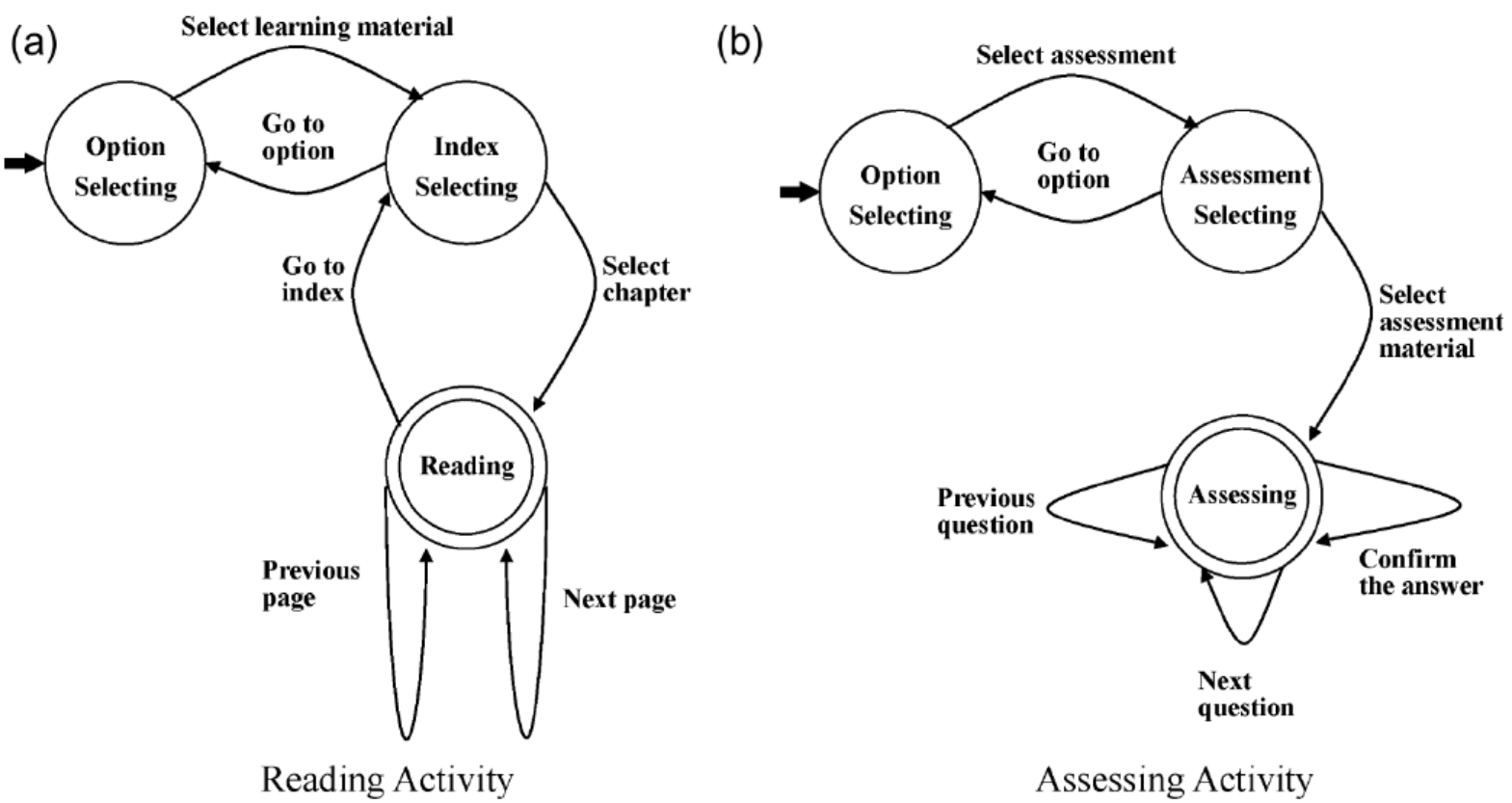


Figure 2 (**a**,**b**) The examples of learning activities.

技术开发过程-状态图

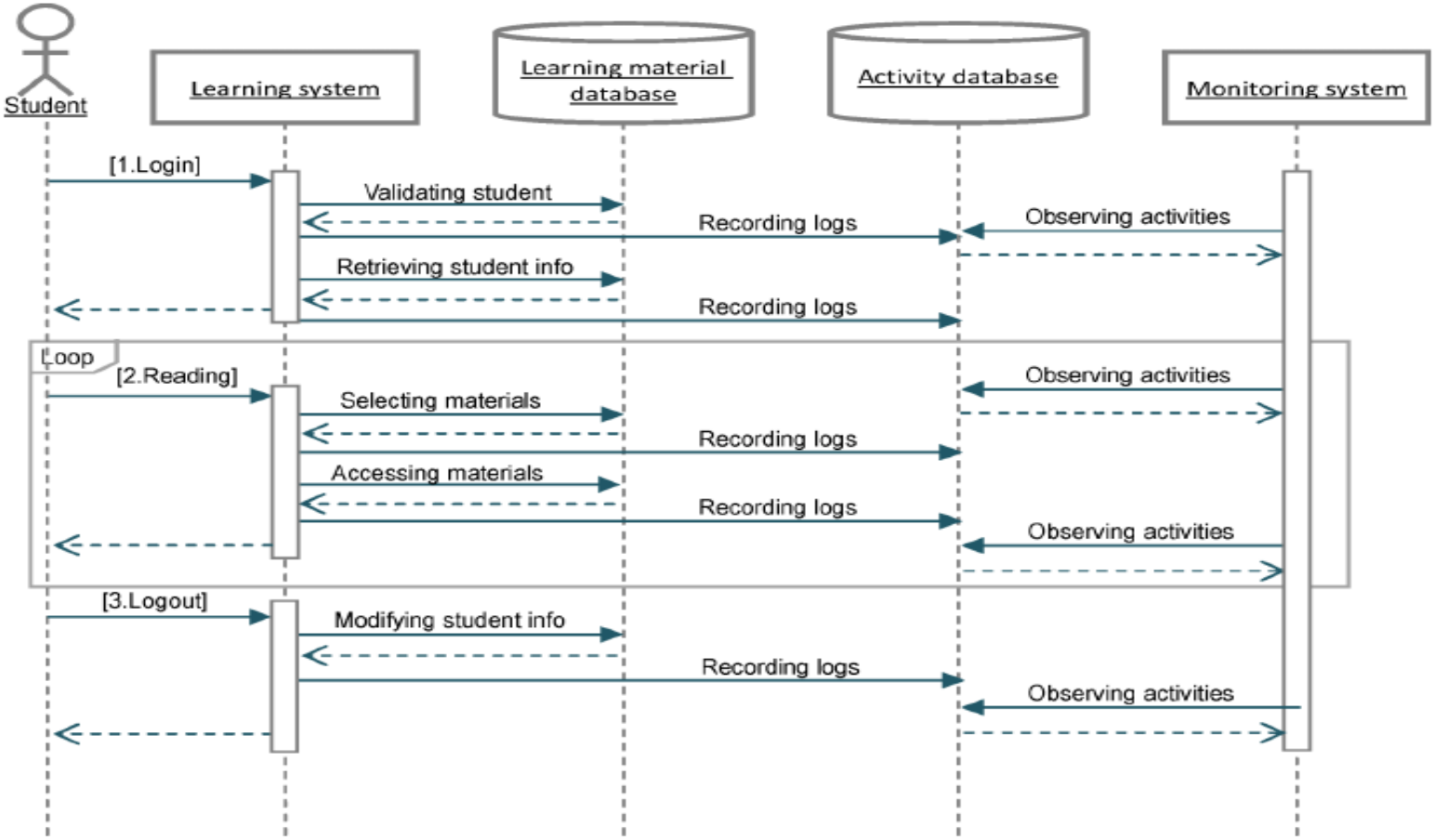


Figure 3 Sequence diagram of reading learning activities.

技术开发过程-序列图

技术开发过程-序列图

- **序列图主要用于展示对象之间交互的顺序**
- 序列图将交互关系表示为一个二维图。纵向是时间轴，时间沿竖线向下延伸。横向轴代表了在协作中各独立对象的类元角色。类元角色用生命线表示。当对象存在时，角色用一条虚线表示，当对象的过程处于激活状态时，生命线是一个双道线。
- 消息用从一个对象的生命线到另一个对象生命线的箭头表示。箭头以时间顺序在图中从上到下排列。

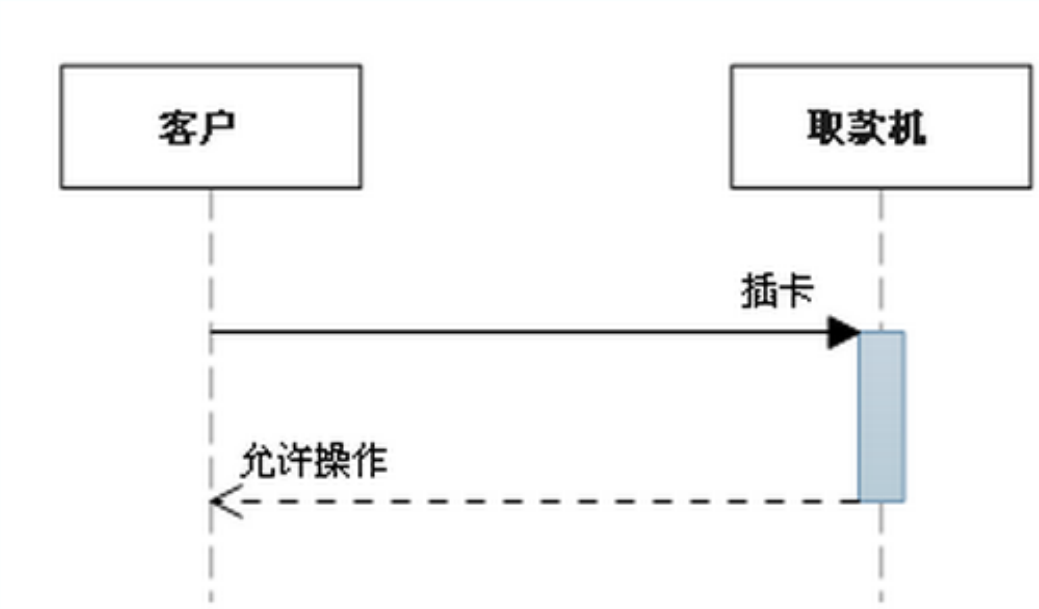
1. 生命线：

生命线名称可带下划线。当使用下划线时，意味着序列图中的生命线代表一个类的特定实例。

技术开发过程-序列图

2. 同步消息

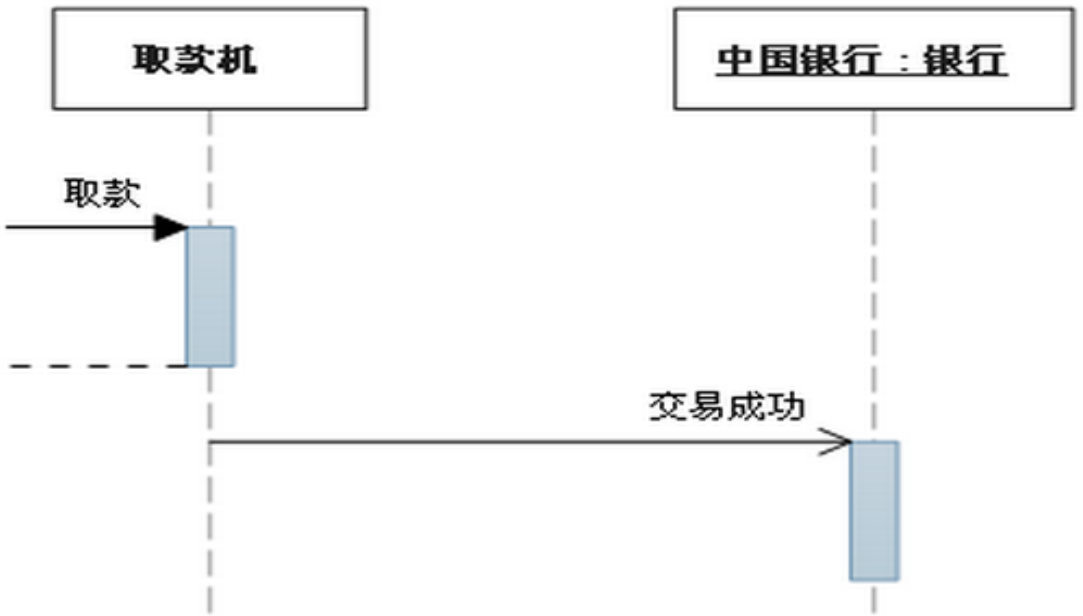
发送人在它继续之前，将等待同步消息响应。



技术开发过程-序列图

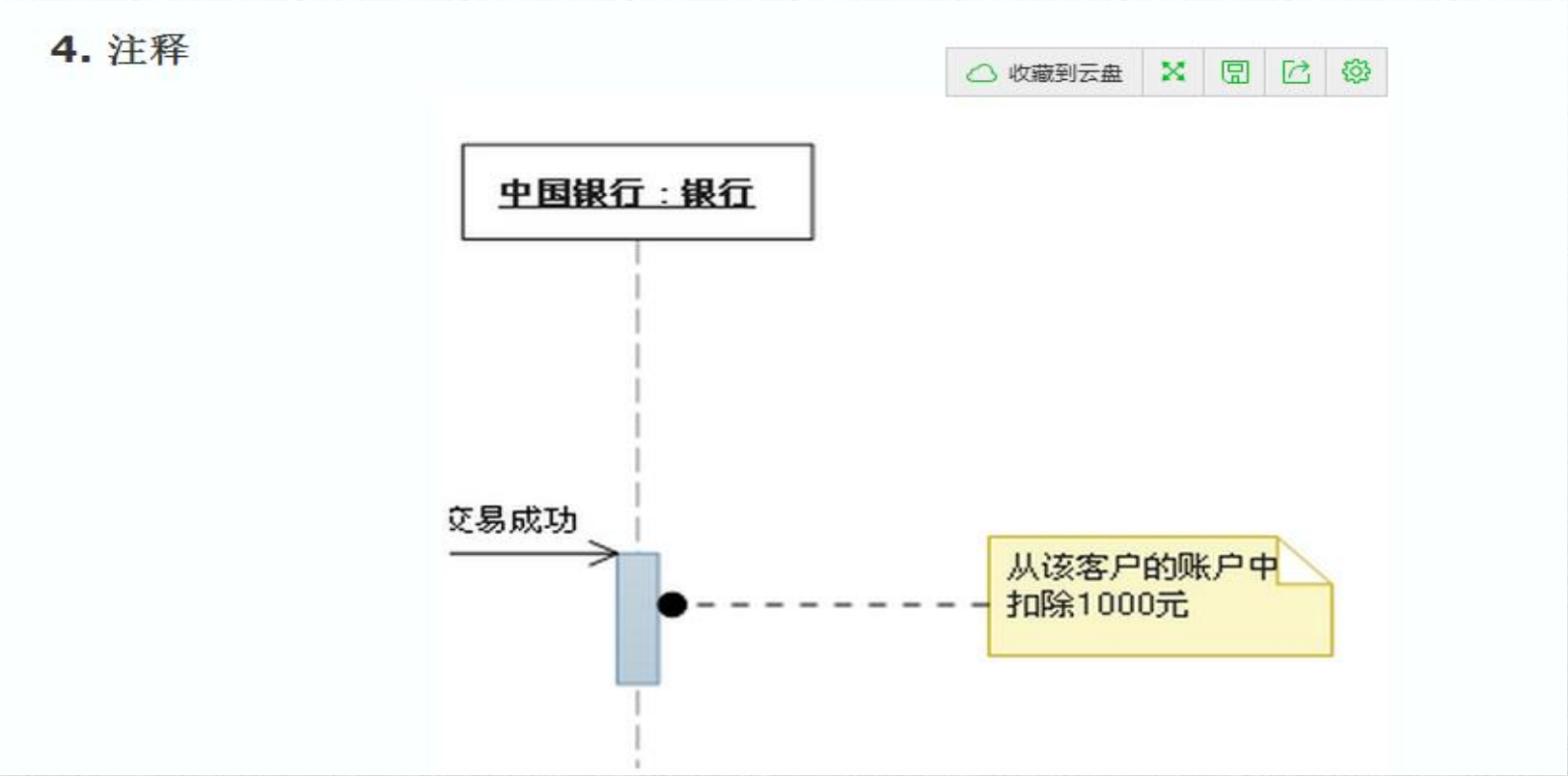
3. 异步消息

在发送方继续之前，无需等待响应的消息。



技术开发过程-序列图

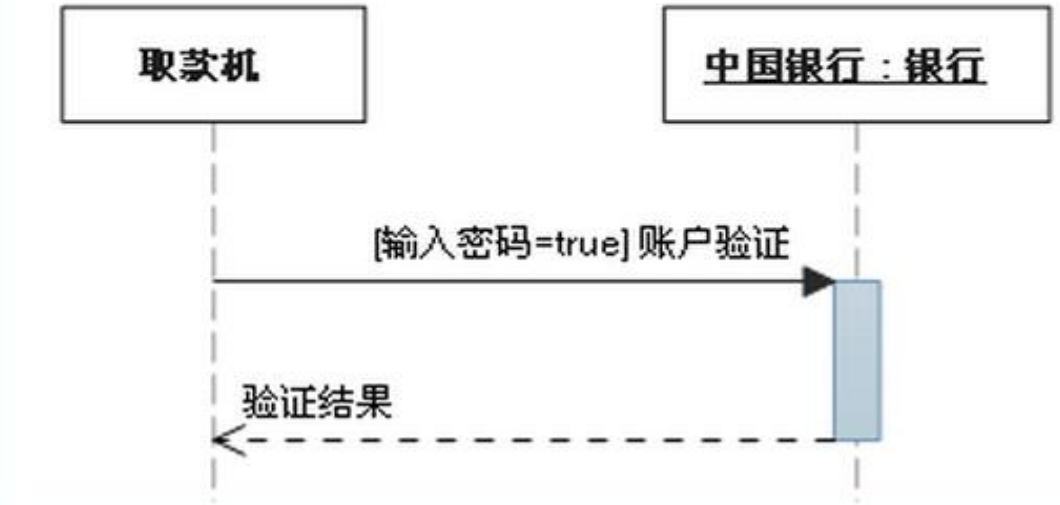
4. 注释



技术开发过程-序列图

5. 约束

约束的符号很简单；格式是：[Boolean Test]



技术开发过程-序列图

技术开发过程-序列图

- 组合片段
- **组合片段用来解决交互执行的条件及方式。**它允许在序列图中直接表示逻辑组件，用于通过指定条件或子进程的应用区域，为任何生命线的任何部分定义特殊条件和子进程。

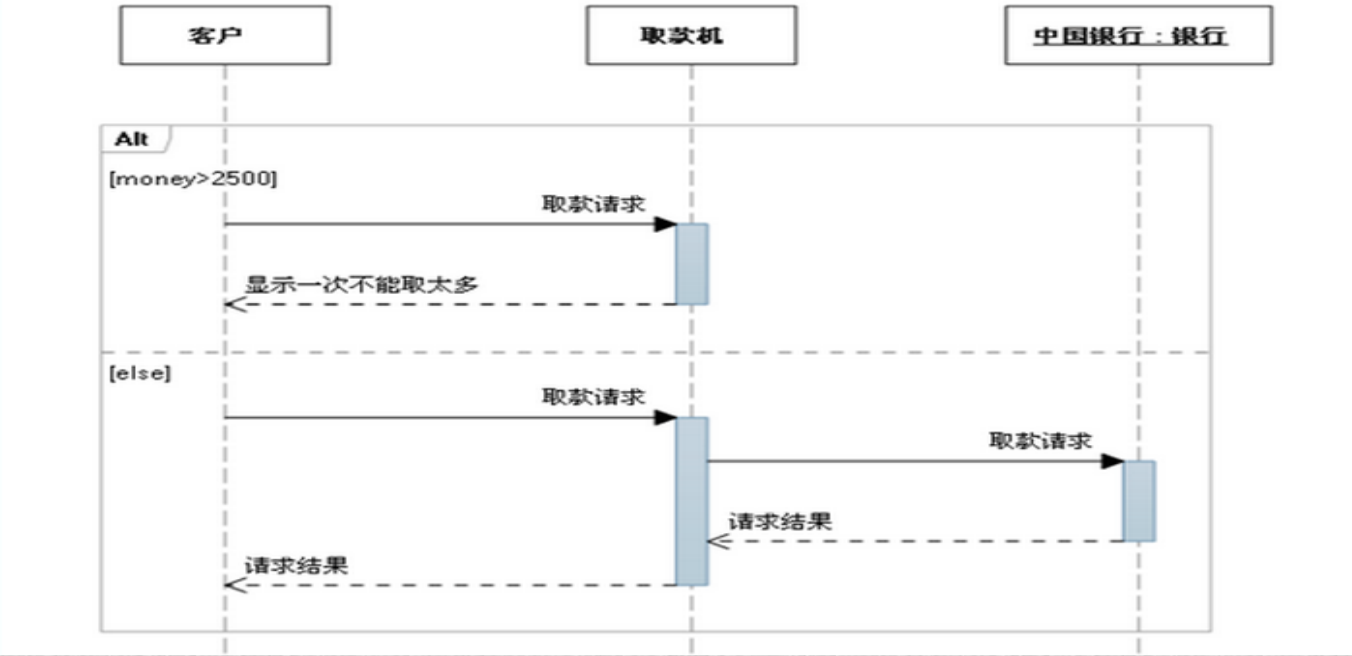
下表列出了常用的组合片段：

片段类型	名称	说明
Opt	选项	包含一个可能发生或可能不发生的序列。 可以在临界中指定序列发生的条件。
Alt	抉择	包含一个片段列表，这些片段包含备选消息序列。 在任何场合下只发生一个序列。 可以在每个片段中设置一个临界来指示该片段可以运行的条件。 **else** 的临界指示其他任何临界都不为 True 时应运行的片段。 如果所有临界都为 False 并且没有 **else**，则不执行任何片段。
Loop	循环	片段重复一定次数。 可以在临界中指示片段重复的条件。 Loop 组合片段具有**"Min"**和**"Max"**属性，它们指示片段可以重复的最小和最大次数。 默认值是无限制。
Break	中断	如果执行此片段，则放弃序列的其余部分。 可以使用临界来指示发生中断的条件。
Par	并行	并行处理。 片段中的事件可以交错。
Critical	关键	用在 Par 或 Seq 片段中。 指示此片段中的消息不得与其他消息交错。
Seq	弱顺序	有两个或更多操作数片段。 涉及同一生命线的消息必须以片段的顺序发生。 如果消息涉及的生命线不同，来自不同片段的消息可能会并行交错。
Strict	强顺序	有两个或更多操作数片段。 这些片段必须按给定顺序发生。

抉择（Alt）

抉择用来指明在两个或更多的消息序列之间的互斥的选择，相当于经典的if..else..。

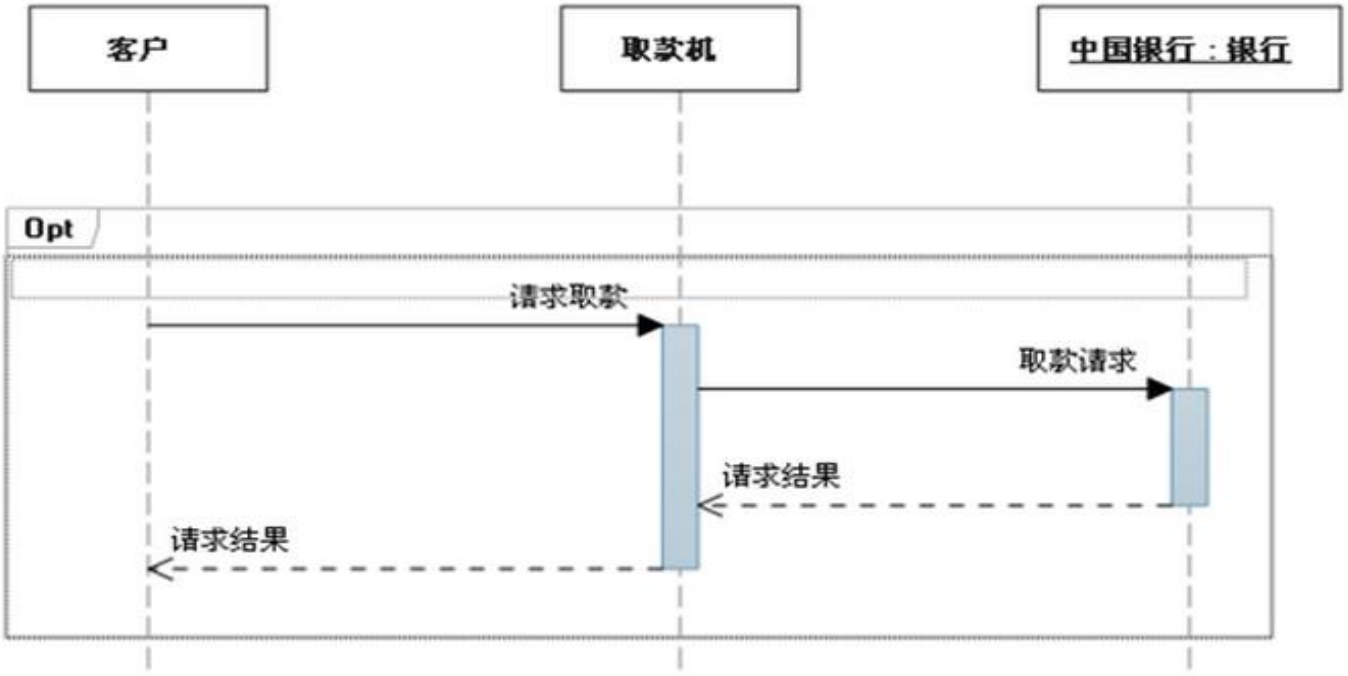
抉择在任何场合下只发生一个序列。 可以在每个片段中设置一个临界来指示该片段可以运行的条件。**else** 的临界指示其他任何临界都不为 **True** 时应运行的片段。如果所有临界都为 **False** 并且没有 **else**，则不执行任何片段。



技术开发过程-序列图

选项（Opt）

包含一个可能发生或不发生的序列

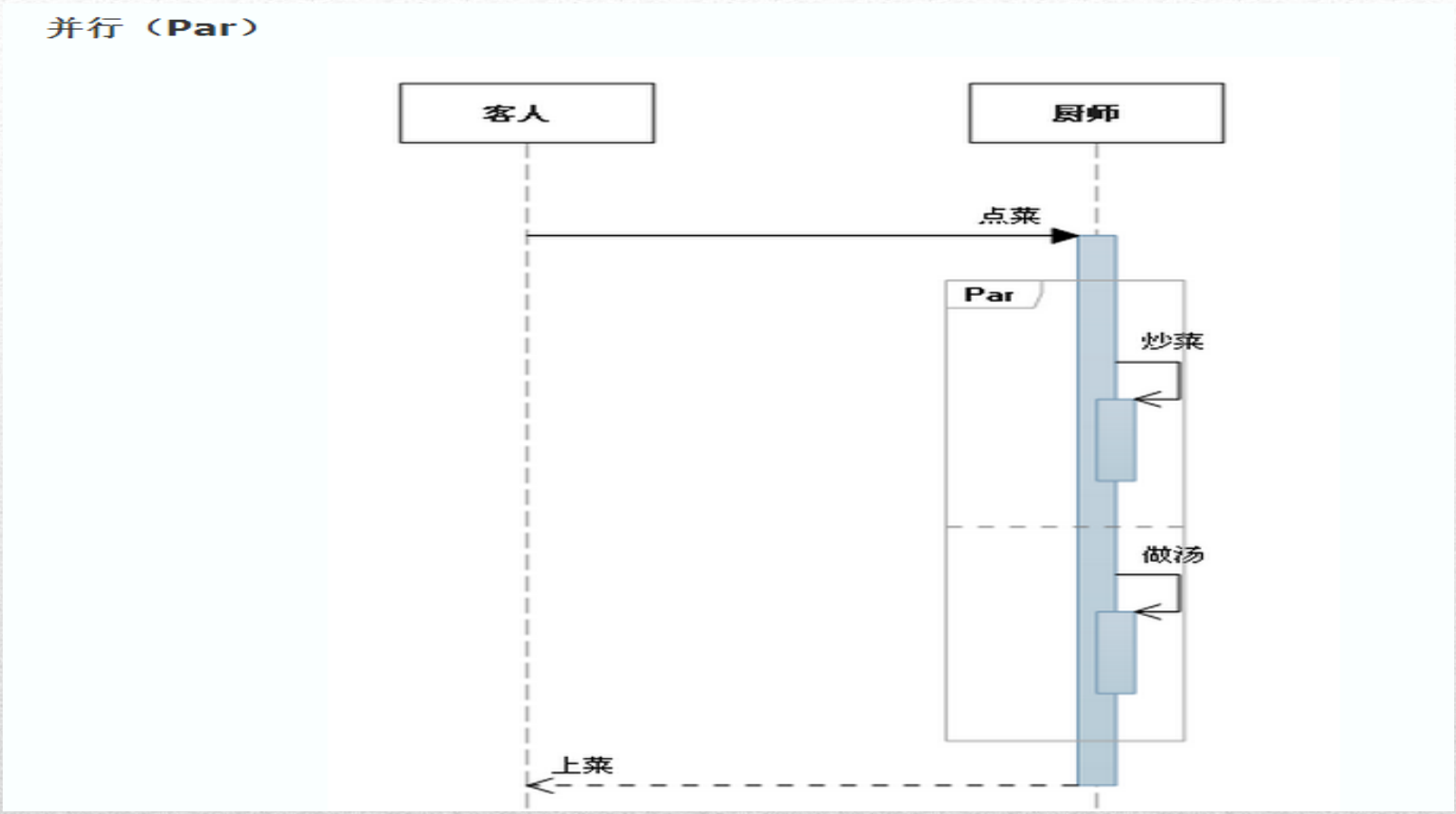


技术开发过程-序列图

循环（Loop）

片段重复一定次数。 可以在临界中指示片段重复的条件。

技术开发过程-序列图



技术开发过程-序列图

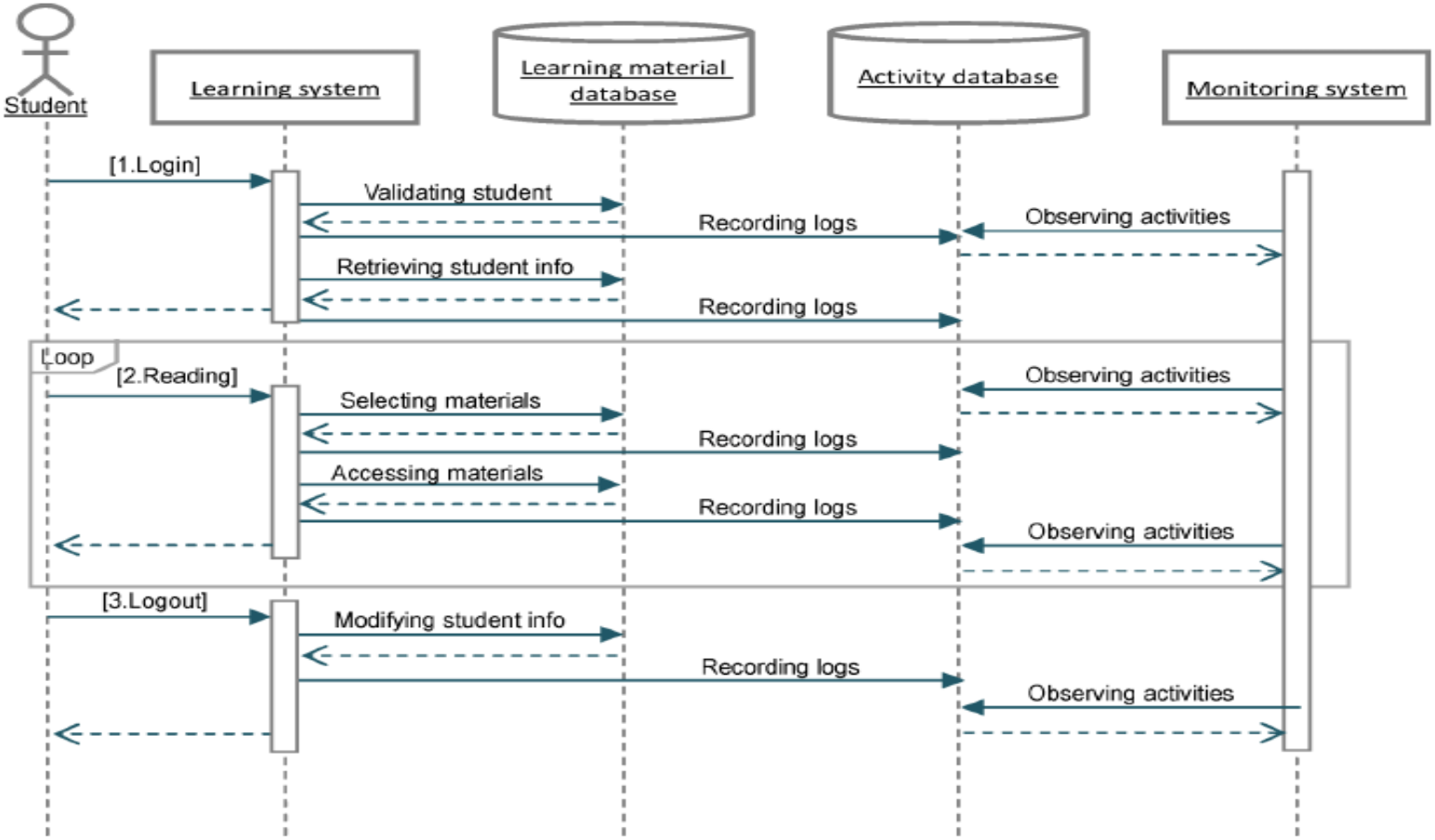
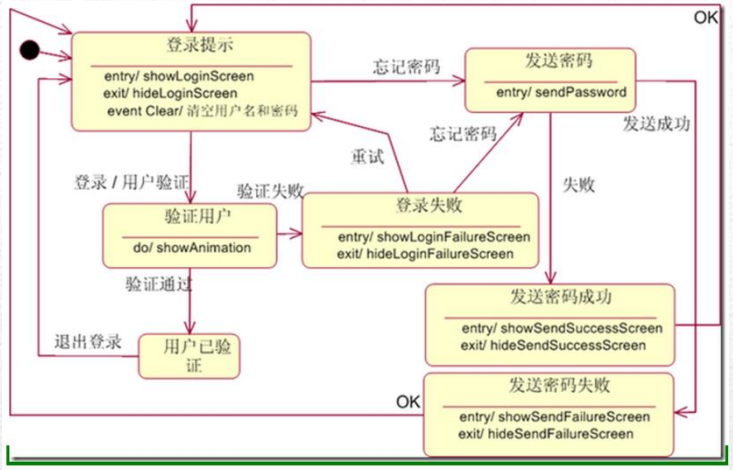
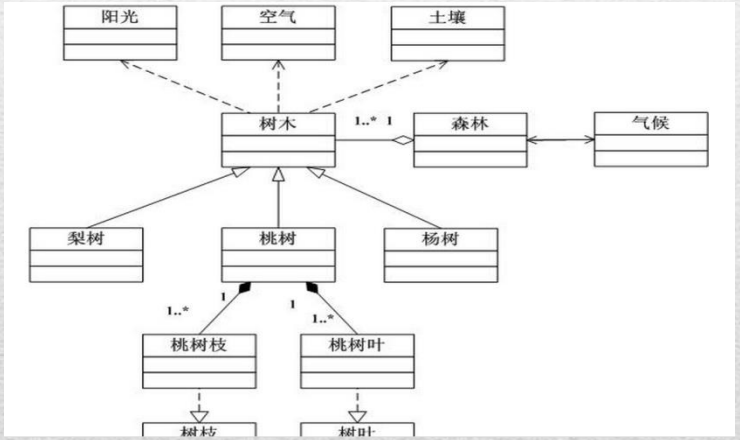


Figure 3 Sequence diagram of reading learning activities.

技术开发过程-序列图

- 类图
- 状态图
- ……..
- UML
- 开发工具





技术开发过程-其他图

Situation 1: The abnormal activity of *Idle* is when the student stays in the learning system for time $t_n - t_l$ or when $t_{j+1} - t_j$ is higher than the threshold of θ_t, where t_n is the current time of system, t_l is the time that the student enters the current state, and t_j is the time when the student enters the jth state. Thus, $t_n - t_l$ denotes the current idling time of the student and $t_{j+1} - t_j$ denotes the idling time of the student in the jth state. θ_t Each activity can have different threshold values of idle time.

These students should be noticed and guided to go back to the normal learning status. The algorithm to detect students locating in the *Idle* situation is defined as follows:

Situation 2: The abnormal activity of *Rush* is when the student in the learning system and the frequency of transition among the states is greater than f_α, where f_α is the threshold of the system that determines if the student is rushing or not. $(T(k,i))/t_k - t_i$ is the frequency of transitions from the ith state to the kth state, and the kth state is the locating state of student. The term $T(k, i)$ denotes the number of transition times from the ith state to the kth state, and t_i and t_k are the times at which the student enters the ith and kth states, respectively. Different activities could have different thresholds for the frequency of transitions among states.

不正常学习活动情境-懒惰

不正常学习活动情境-急速

技术开发过程-算法开发

Algorithm 1: Abnormal Activity Checker for *Idle* Situation.
Input: The learning portfolio of the student.
Output: The *Idle* situation of the student.
S_s = the state of the student logins the learning system
T_s = the time that the student enters S_s
while the student studying in the learning system **do**
  if T_r is expired then
    S_c = the current state of the student
    T_c = the current time
    if $S_s = S_c$ then
      if $T_c - T_s > \theta$ then
        send the *Idle* alarm message
      endif
    else
      $S_s = S_c$
      T_s = the time that the student enters S_s
    endif
  endif
endwhile

Algorithm 2: Abnormal Activity Checker for *Rush* Situation.
Input: The learning portfolio of the student.
Output: The *Rush* situation of the student.
  while the student studying in the learning system **do**
    if the student changes the learning state **then**
      T_c = the current time
      if Queue_T is full **then**
        pop T_n from Queue_T
        push T_c into Queue_T
        if $\frac{T_c - T_n}{n} > f_\alpha$ **then**
          send the *Rush* alarm message
        endif
      else
        push T_c into Queue_T
      endif
    endif
  endwhile

不正常学习活动检测算法描述

技术开发过程-算法开发

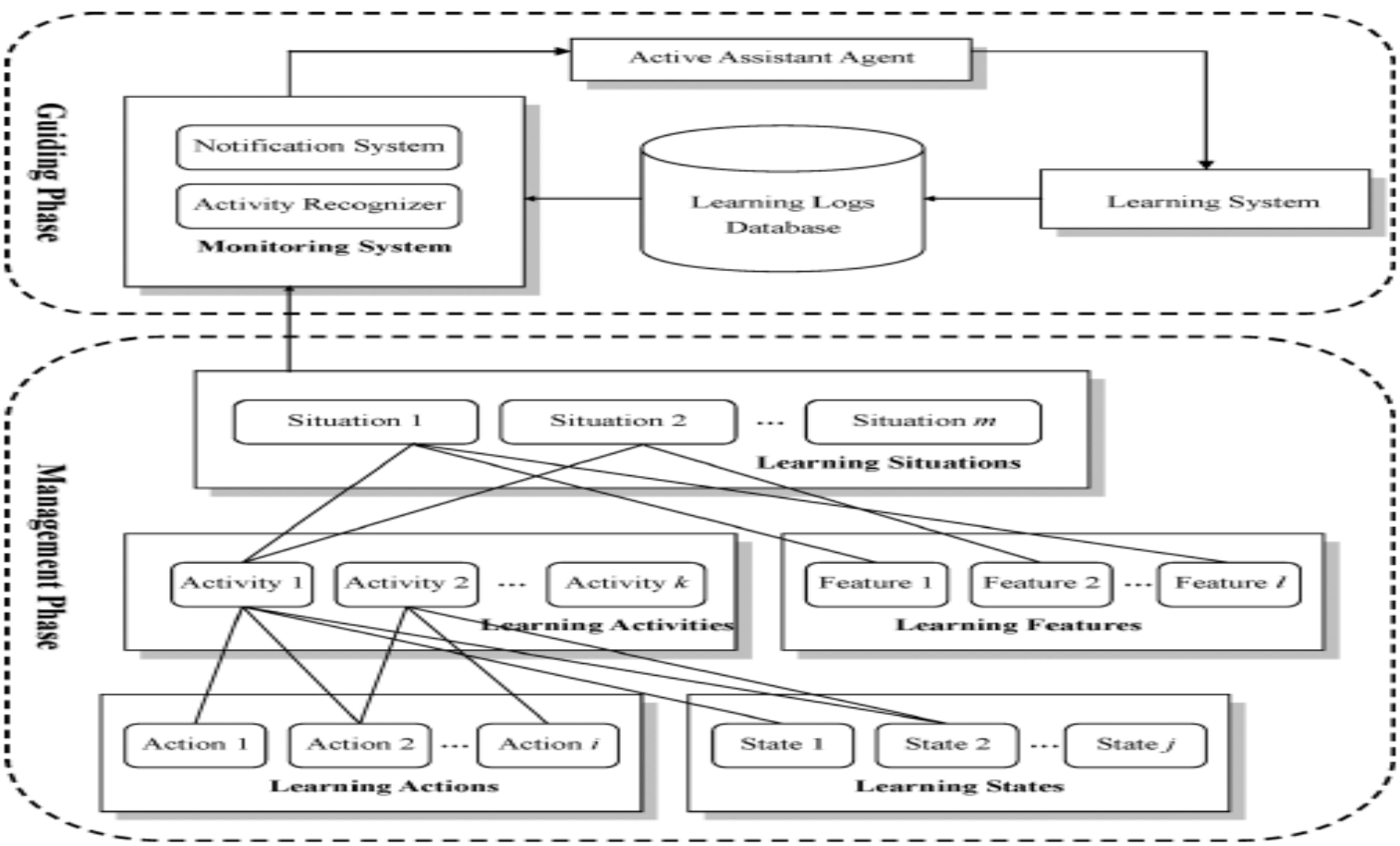


Figure 4 The system architecture.

技术开发过程-系统框架图

SYSTEM IMPLEMENTATION AND PROTOTYPE

The proposed system was implemented with PHP using Ajax scripts coupled with a MySQL database. The system consists of two parts, including a learning system and a management system. The learning materials were obtained from the Cisco net-

技术开发过程-系统开发实现

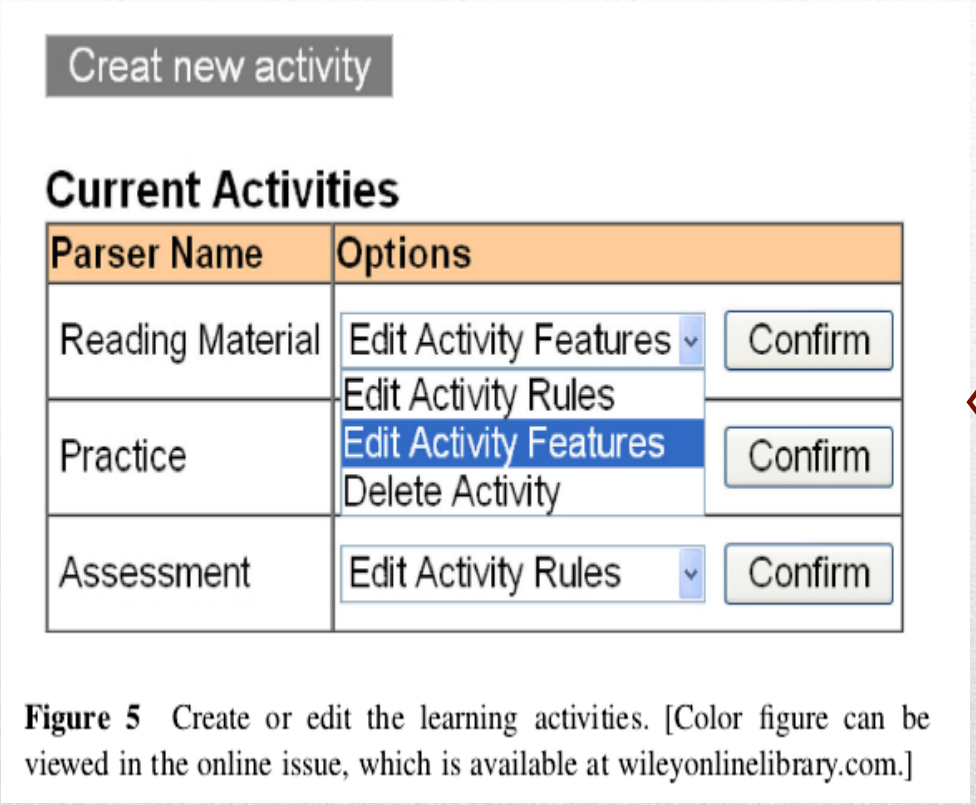


Figure 5 Create or edit the learning activities. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

学习活动创建与管理：
编辑学习活动规则；
编辑学习活动特征；
删除学习活动。

技术开发过程-原型界面图

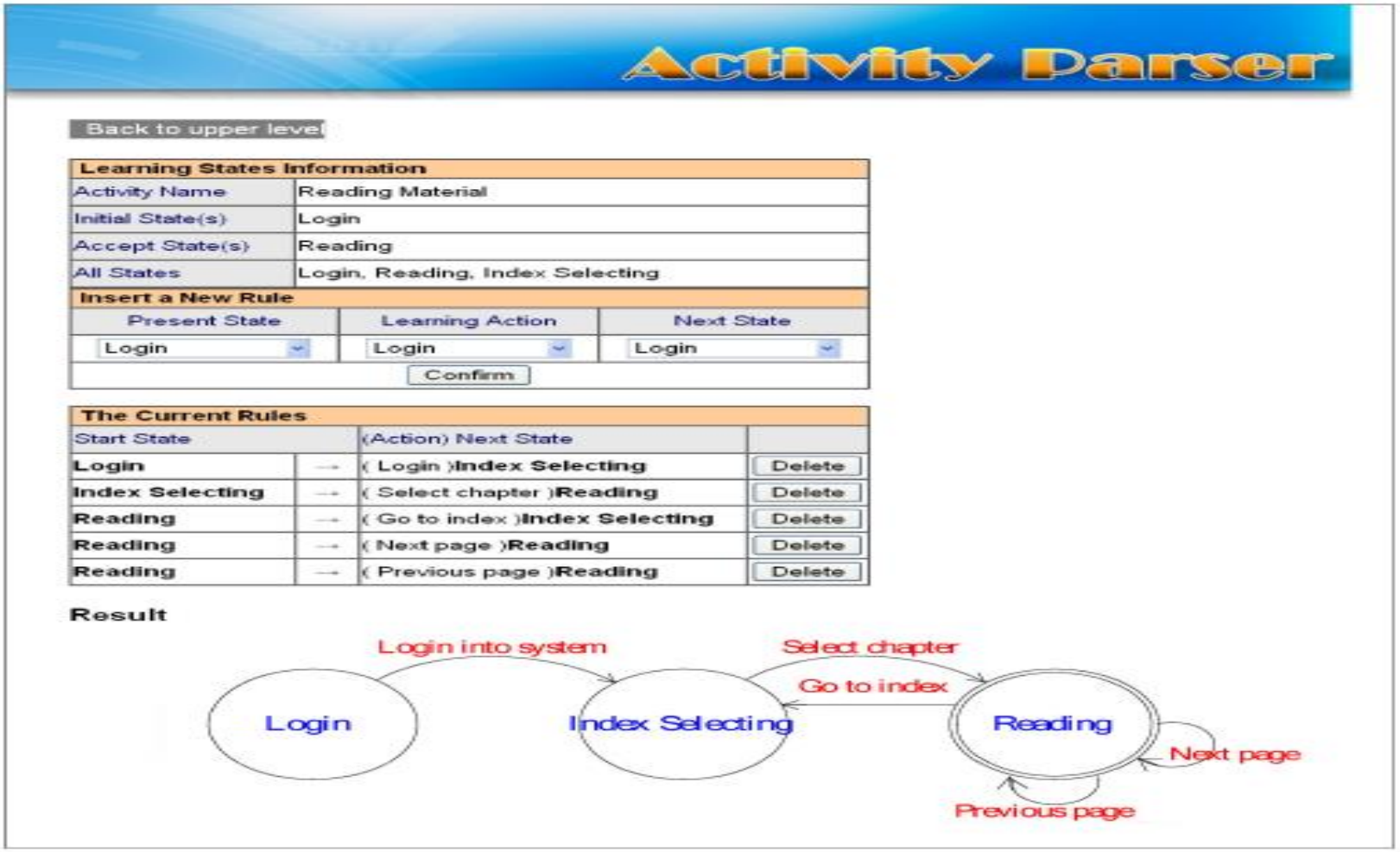


Figure 6 The snapshot of learning activity management page. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

学习活动状态信息及规则描述。

技术开发过程-原型界面图

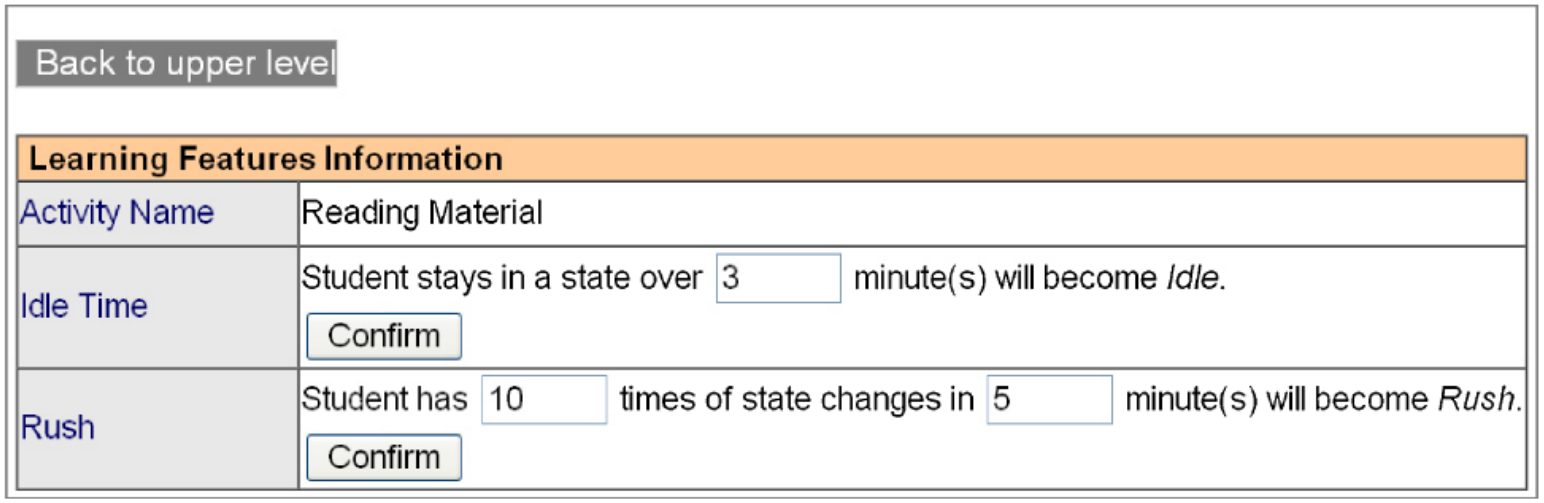


Figure 7 The learning features of reading material activity. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

不正常学习活动特征描述（Idle & Rush）

技术开发过程-原型界面图

- The experimental subjects were undergraduate students from two computer networks classes. Fifty-seven and 58 students were assigned to the experimental and control groups, respectively.

技术开发过程-系统评价

Table 1 The Grades of Pre-Test Phase

	Experimental group	Control group
Number of students	57	58
Average score	68.9	63.6
Standard deviation of score	14.7	14.0
Average number of idle times	6.0	5.5
Average number of rush times	2.5	2.0

Table 2 The Grade of Test Phase for Experimental Group With Guiding

	Experimental group	Control group
Number of students	57	58
Average score	88.1	74.3
Standard deviation of score	12.2	14.1
Average number of idle times	4.4	5.1
Average number of rush times	0.8	1.2

Table 3 The Grade of Test for Students in Experimental Group

	Students	
	Advanced guiding	Basic guiding
Number of students	12	45
Average scores of pre-test	66.4	71.2
Average scores of test	88.0	88.1
Average number of idle times	5.0	3.6
Average number of rush times	1.5	0.8

技术开发过程-系统评价

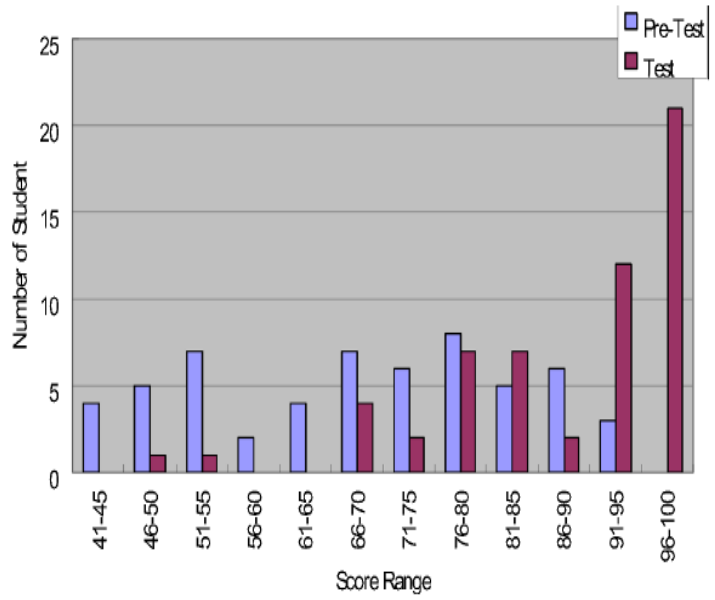
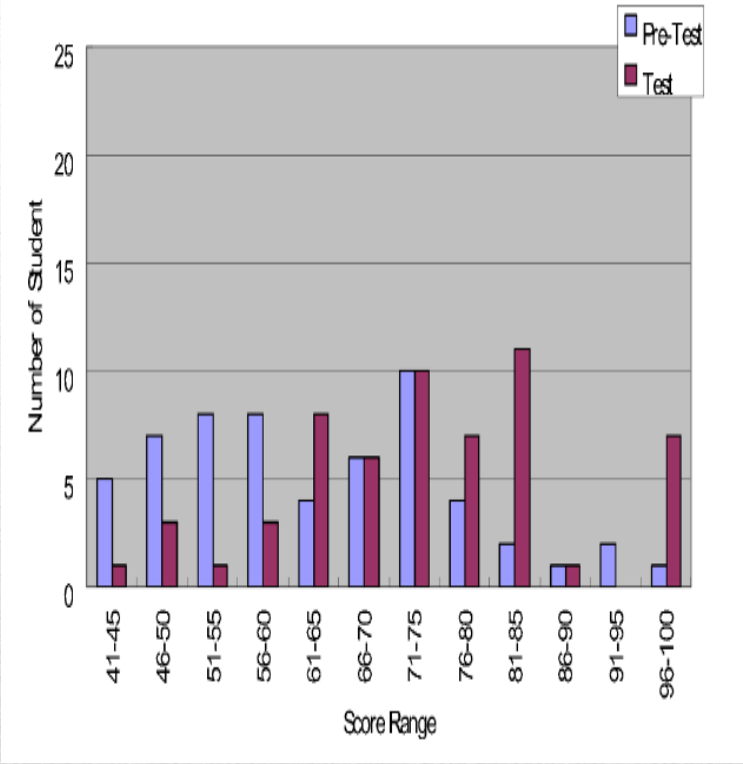
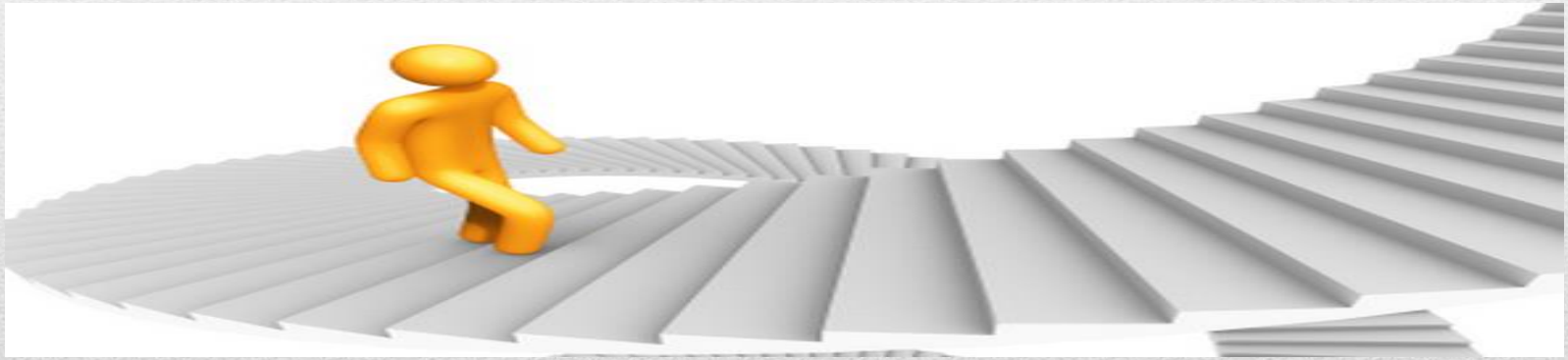


Figure 9 The distributions of the scores in the experimental group. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]



技术开发过程-系统评价

确定教学研究问题 → 设计关键技术模型算法 → 系统架构模块功能描述 → 编码实现原型系统界面 → 技术实验评价



技术开发法-步骤总结

- 实际研究中技术开发法一般要和其他定量和定性研究方法结合使用。
- 采用技术开发法描述时侧重介绍关键特色的技术模型、算法、系统架构和主要的原型系统界面。
- 技术开发法侧重解决教学中的实践问题。

技术开发法总结

Thanks