

**AN EXPERIMENTAL STUDY OF THE EFFECTS OF A  
BAYESIAN KNOWLEDGE TRACING MODEL ON STUDENT  
PERCEIVED ENGAGEMENT**

by

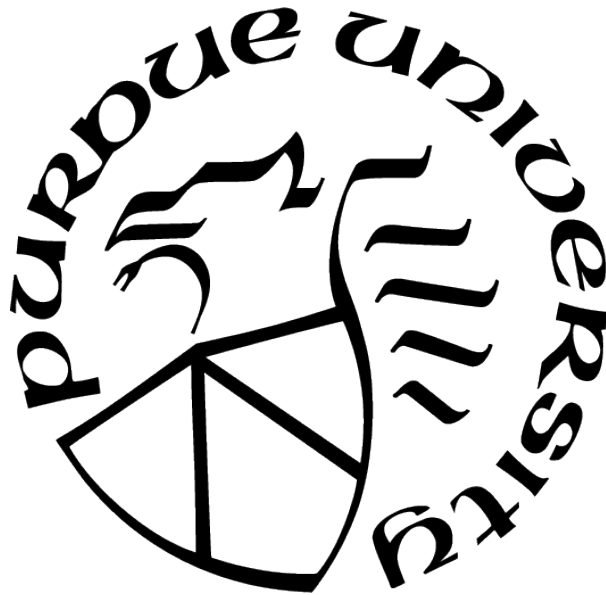
**Arjun Kramadhati Gopi**

**A Thesis**

*Submitted to the Faculty of Purdue University*

*In Partial Fulfillment of the Requirements for the degree of*

**Master of Science**



Department of Computer and Information Technology

West Lafayette, Indiana

December 2021

**THE PURDUE UNIVERSITY GRADUATE SCHOOL  
STATEMENT OF COMMITTEE APPROVAL**

**Dr. Dominic Kao, Chair**

Department of Computer and Information Technology

**Dr. Baijian Yang**

Department of Computer and Information Technology

**Dr. Alejandra J. Magana**

Department of Computer and Information Technology

**Approved by:**

Dr. John A. Springer

Dedicated to Appa. Though the pandemic finally shook you, your memories remain safe in my keeping, through all laughter and some tears, forever pristine.

## ACKNOWLEDGMENTS

Dr. Michael J Dyrenfurth's guidance and constant support have proved invaluable in writing and formatting this thesis proposal. Dr. Dominic Kao, being the advisor and the committee chair of the researcher's thesis study, has been constantly involved in the research study right from the idea generation stage. His timely feedback and guidance on the weekly progress of the researcher have been instrumental in allowing the researcher to complete the study. Dr. Alejandro J Magana and Dr. Baijian Yang have also played a very crucial role in helping shape the research study. Lastly, the researcher would like to extend appreciation and acknowledgment to Purdue's unwavering support of research. The Department of Computer and Information Technology must also be thanked for making this research study possible.



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## ABBREVIATIONS

AI	Artificial Intelligence
ITS	Intelligent Tutoring System
STEM	Science, Technology, Engineering, and Mathematics
MOOCs	Massive Open Online Courses
DNN	Deep Neural Network
SVM	Support Vector Machine
KT	Knowledge Tracing
BKT	Bayesian Knowledge Tracing
DKT	Deep Knowledge Tracing
DSC	Dynamic Student Classification
RNN	Recurrent Neural Network
LSTM	Long short-term memory
PD	Problem Difficulty
MAR	Missing at Random
KNN	K-Nearest Neighbors

## ABSTRACT

With the advent of Machine Learning and Deep Learning models, many avenues of development have opened. Today, these technologies are being leveraged to perform a wide variety of tasks that were otherwise not possible with traditional systems. The power of Machine Learning and Artificial Intelligence makes it possible to compute very complicated tasks at near real-time speeds. To provide an example, Machine Learning models are used extensively in the retail industry to predict and analyze critical parameters such as sales, promotions, customer behavior, recommendations, and offers [1].

Today, it is increasingly common to observe AI being used across many of the biggest domains such as Health, Environment, Military, and Business. Artificial Intelligence being used in educational settings has thus been a growing field of focus and study. For example, conversational AI being deployed to act as virtual tutors to answer student questions and concerns [2], [3]. Additionally, there is a fill-the-hole type of AIs that will help students learn tasks such as coding by either showing them how to do it or by predicting where the student might go wrong and suggesting preemptive corrective steps [4]–[6].

As described, a great deal of literature exists about the use of Deep Learning and Machine Learning models in education. However, the existing tools and models act as external appendages that add to the course structure, thereby altering it. This proposed study introduces a Bayesian Knowledge Transfer model based on the Long Short Term Memory structure (BKT-LSTM) utilized in a live STEM (Science, Technology, Engineering, and Mathematics) classroom. The model discovers individual student learning profiles based on past quiz performance and customizes future quizzes based on the learned patterns. The BKT-LSTM model works in tandem with the existing course curriculum and only tests those knowledge items that have already been covered in the classroom. The model does not change the course structure but rather aims to improve the student’s learning experience by focusing on areas of the student’s knowledge that require more practice in learning.

Within a live STEM classroom, the BKT-LSTM model acts as a herald of change in the way students interact with the curriculum, even though no major changes are observed in the course structure. Students interacting with the model are subjected to quizzes with

questions that target the individual student's lack of learning in particular knowledge areas. Thus, students can be expected to perceive the change as unwelcoming due to the increasing difficulty in subsequent quizzes. Regardless, the study focuses on measuring the learning performance of the students. Do the students learn more in the new system? Another focus of the study is the student's perception of engagement while interacting with the BKT-LSTM model. The effectiveness of the new educational process is determined not only by increased student learning performance, but also by the student's perception of engagement while interacting with the model. Are the students enjoying the new experience? Do the students feel like they are learning something? Another important factor was also studied, that is learning performance of students interacting with the BKT-LSTM. This is not covered in the current thesis but is covered in detail in [7].

# 1. INTRODUCTION

The long term goal of this research study is to examine the effects of having a completely virtual Teaching Assistant (TA) employed within a STEM course delivery. Virtual TAs can be thought of as intelligent tutoring systems which can do the following tasks:

1. Answer student questions to a satisfying degree that enables students to carry out their tasks or to ask the next logical question in the process of learning a concept.
2. Intelligently cater to individual students by keeping track of and evaluating student performance based on a unique student ID.
3. Determine the subject area in which the student needs additional academic support.
4. Challenge the students within the proper subject areas to the proper extent, so as to boost their capacity to learn.
5. Recommend resources for further study and reference.
6. Provide live and round the clock support to students needing help in the subject domain.

This is the long-term goal of the research study. The investigators wish to begin by answering specific questions about the effectiveness of BKT-LSTM in STEM.

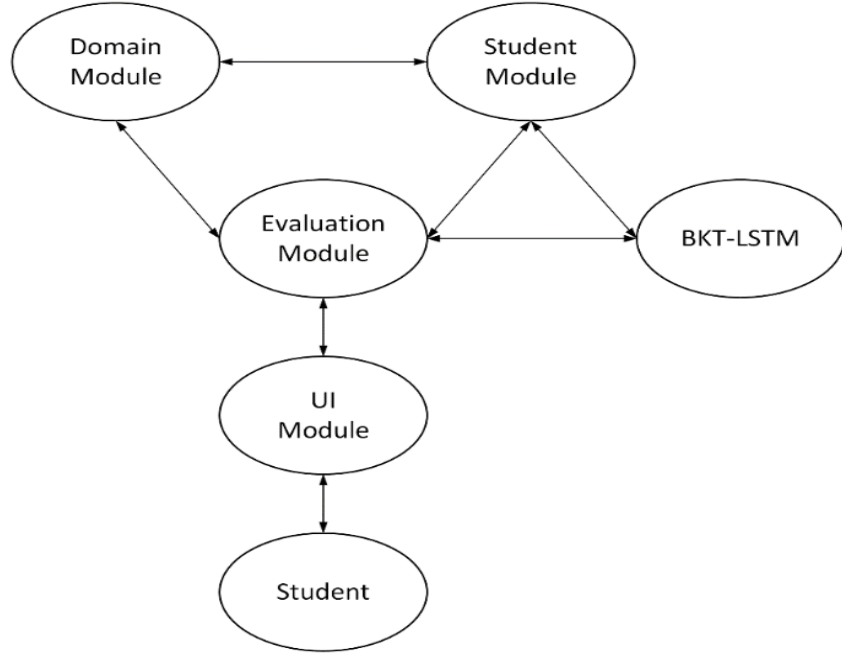
Intelligent Tutoring System (ITS) have been popularized during the end of the prior century owing to the rise of the computing power employed by Machine Learning and Artificial Intelligence processes [8]. The main parts of a general Intelligent Tutoring System (ITS) system includes the following four parts [9]:

1. Domain module: This module serves as the knowledge node for all domain related information in the entire system. For instance, the domain for our proposed research study is STEM, specifically a course in JAVA (Object Oriented Programming). The domain module will have all necessary information for the evaluation module, as well as the GUI module which will be displaying relevant information for the user. This



necessary information will include all background information on the subject matter, and questions regarding the subject matter as well.

2. User module: This module will house the information necessary to build and pre-process the data in the right format to be used by the evaluation module for either training or inferencing.
3. Evaluation module: The main module of the entire system is arguably the evaluation module. This is the module which is responsible for processing the inputs that are coming in from the user-interface (UI) module and the other communicating modules. The evaluation module will be involved in producing actionable inferences from the data. For example, the evaluation module will be analyzing the user inputs for correctness. Further, the evaluation module will be recommending 'next-questions' to the users. The evaluation module will be constantly trying to evaluate and monitor where the student is lacking and what areas of the subject the student has to be exercised and tested more. Hence, this module is a very crucial module which will be acting as the collective decision maker of the entire system.
4. UI module: The UI module is the user facing Graphic User Interface will act as the point of contact with the end users. The users (in this case the students) will be interacting with a GUI in one form or the other. It is the UI's role to effectively convey the proper messages, in the proper order, and in the proper format. The UI must be intuitive and should not require effort by the user to get used to it. The UI should also minimize its interference with information retrieval and delivery flow.



**Figure 1.1.** *Concept map for a general ITS with an added appendage which is the BKT-LSTM module*

Figure 1 shows a modified concept diagram of our proposed ITS systems design. At the top, the domain module and the student module will communicate with the evaluation module. The extra module added (BKT-LSTM) to the concept map shows that it is not directly a part of the evaluation module. The BKT-LSTM module will be communicating with both the student module as well as the evaluation module. More details about the BKT-LSTM are laid out in the following sections of the document.

## 1.1 Problem

As already mentioned, the study is two-pronged. One part of the study focuses on analyzing the learning performance of students who interact with the BKT-LSTM model. The other part of the study focuses on measuring the student's perception of engagement while interacting with the newly introduced model. Both the studies are based on the hypothesis that using the BKT-LSTM to frame adaptive quizzes will create an observable

change in student learning performance, as well as in the perception of engagement of the students.

In the traditional academic setting, students are graded on weekly quizzes and other exams. Often, the further follow-up action that is taken to rectify those areas where the student was having trouble with is mostly either insufficient or too late in the educational timeline, creating insufficient student understanding of concepts and lower grades on subsequent learning assessments.

The motivation behind this effort is to employ the BKT-LSTM model in a STEM program in such a way as to aid student learning concepts in STEM courses. The motive is not to prove that the model can replace or supplant traditional methods of teaching. Rather, the aim is to show that BKT-LSTM can become an invaluable tool for the teachers of STEM courses to boost both student learnability student motivation.

The current traditional method of delivering course content includes the following general structure (in STEM programs):

- Class lectures use multimedia to teach the course syllabus to the class. Multimedia presentations need not be the norm, as some of the lectures rely solely on the class notes.
- Lab handouts with written instructions of the lab programs are given to the students. These handouts will include the following details:
  1. Lab objectives and goals.
  2. Instructions to set up the necessary platforms to complete the lab objectives.
  3. Some necessary guidelines and information on how to complete the lab programs.
  4. Sample output which will serve as the expected output.
- Labs are conducted with Teaching Assistants who guide the students through implementing the lab objectives and goals to achieve the expected outputs.
- Weekly quizzes, in-class assignments, midterm exams and final examinations.

- A final project is either a group project or an individual student project which showcases all the materials covered throughout the course of the class.

In the current traditional approach to teaching STEM, there are no methods in place to reinforce student learning. Foreexample, a student in the CNIT 25501 Introduction to Object Oriented Programming will be studying about many broad topics, as revealed in Figure 2:

#### Calendar

Subject to Change with Notice

Week	Date	Topic	Date	Topic	Lab Due
1			1-20	[0] Introduction	
2	1-25	[1] Java (ch. 1, 2.1-2.3)	1-27	[2] Variables/Data (ch. 3.1-3.5)	Lab 0
3	2-01	[3] Strings I/O (ch 3.6-3.7)	2-03	[4] Control Flow (ch. 3.8)	
4	2-08	[5] Arrays 3.9-3.10	2-10	[6] Classes (ch. 4.1-4.3)	Lab 1
5	2-15	[7] Classes (ch. 4.4-4.6)	2-17	Reading Day (No Classes)	
6	2-22	[8] Classes (ch. 4.7-4.10)	2-24	[9] Multi-class Systems	Lab 2
7	3-01	[10] Inheritance (ch. 5.1)	3-03	[11] Inheritance (ch. 5.2-5.4)	
8	3-08	[12] Inheritance (ch. 5.5-5.8)	3-10	[13] Basic GUI (basic ch. 10, 12)	
9	3-15	[14] Basic Events (ch. 11.1-11.2)*	3-17	Midterm 1 Exercises	Lab 3
10	3-22	Midterm 1 Exercises	3-24	[16] Interfaces (ch. 6.1-6.2)	
11	3-29	[17] Inner Classes (ch. 6.4)	3-31	[18] Exceptions (ch. 7.1-7.2)	Lab 4
12	4-05	[19] Exceptions (ch. 7.3-7.6)	4-07	Midterm 2 Exercises	
13	4-12	Midterm 2 Exercises	4-14	Project Work	
14	4-19	Project Work	4-21	Presentations	
15	4-26	Presentations	4-28	Presentations	

Labs are due Friday at midnight.

For more details, see Lab Policies & Expectations.

\*Lecture 15 will be a review lecture released prior to the Midterm 1 Exercises.

**Figure 1.2.** *Course Syllabus of CNIT 25501 Introduction to Object Oriented Programming*

The objective of the class is to serve as a solid introduction to object-oriented programming using JAVA software. Should a student have trouble understanding a concept such as Inheritance (as appears in class 11 in Figure 2), the student has the following options and resources from which to get help:

1. The student can consult the class slides on the course website and review the necessary topics.
2. The student can seek help from either the Instructor or the Teaching Assistants of the class.

If the student is still having trouble with the concepts after taking these actions, this will be reflected in the level of student performance on the subsequent weekly quizzes, labs and the midterms, as the student will not be able to properly answer the questions arising from those topics in which he/she is lacking true learning. The same grades will carry through to the final examinations. Ultimately, the student might pass the course knowing that a certain topic was not mastered.

## **1.2 Significance of problem**

Researchers [8], [10] have described the increasing attention being given to the field of AI being used in an educational setting. However, the success of AI in other fields of engineering and common applications has not entirely translated to the field of education. The educational community still relies mainly on the human-to-human interaction method of teaching [8].

The demand for smart education has risen significantly in recent years. AI is increasingly being employed in the field of education under a variety of use cases, with each trying to teach students using custom tutored teaching methods.

However, one reason why such ITS systems are not more popularly employed in education is because of the lack of the human element in these computerized systems. A system that can show a significant boost in both student learnability and student involvement will be more readily accepted into educational settings to act in tandem with traditional education systems to help improve quality of education [11].

## **1.3 Purpose**

There are two working hypotheses going forward with the study:

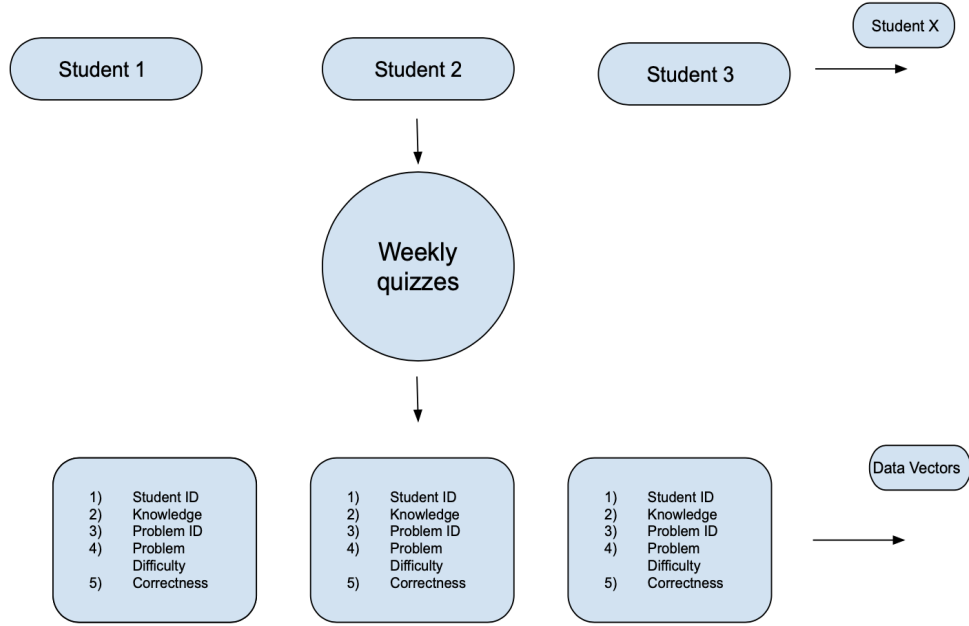
1. Using BKT-LSTM will improve the true performance of students, as observed by their increased conceptual retention of concepts achieved through repeated reviewing of those concepts identified as lacking in student understanding

2. The perception of engagement of students in the learning process will increase. Specifically, student perceptions of enjoyment in the learning process will increase. Due to the increased problem difficulty in targeted reinforcement of unlearned concepts, it is expected that the students using the BKT-LSTM model will perceive less enjoyment in the learning process than the students who interact with traditional quizzes.

### **1.3.1 Indicators**

The student's performance in the weekly quizzes is a good indicator of the student's conceptual hold on topics. The BKT-LSTM is trained on the data from the weekly quizzes. The input for the training of this Machine Learning model is as follows:

1. Unique Student ID
2. Knowledge Label
3. Problem ID
4. Problem Difficulty
5. Correctness Index (0/1)



**Figure 1.3.** *Weekly quizzes to extract indicators for BKT-LSTM model*

Figure 3 explains the concept map of the data structure extracted from the weekly quiz performance records of individual students. The data packets of each student's individual performance will be vectorized based on the five data headers listed above. The idea is to enable the model to identify the student's learning pattern. The knowledge indicator labels include Declaration, Loops, Inheritance, and other concepts that are listed in the class syllabus and are tested on in the weekly quizzes. The unique student ID is an identifying label attached to each student's name in the database. The problem ID is again a unique ID assigned to each unique problem being posed in the weekly quizzes. Problem difficulty is an integer value ranging from 1 to 10. Correctness is a digital value (0 or 1) which tells whether the answer is either wrong or right respectively.

#### 1.4 Research Questions

The specific research questions being posed in this study:

1. **Do the students perceive more enjoyment while interacting with the BKT-LSTM than those interacting with traditional educational models?**

## **2. Do the students perceive more learning while interacting with the BKT-LSTM than those interacting with traditional educational models?**

### **1.5 Significance of purpose**

The research study relies on utilizing the power of a Bayesian Knowledge Transfer model [12] which has a proven record of accurately predicting student performances based on individual student performance history.

Kurt VanLehn [8] put forth the explanation as to why human tutoring is still more effective than Intelligent Tutoring Systems. In the paper the reasons presented are:

1. Detailed Diagnostic Assessments
2. Individualized Task Selection
3. Sophisticated Tutorial Strategies
4. Learner Control of Dialogues
5. Broader Domain Knowledge
6. Motivation
7. Feedback
8. Scaffolding

The study incorporates a BKT-LSTM model that captures most of the above-mentioned points through the correlations in the data. The model assesses the student performance at each time interval and predicts student performance based on the personalized problem difficulty level. Therefore, the model will be able to cater customized questions to students. The model can boost student motivation through an iterative process that employs scaffolding of those lacking concepts for individual students. The significance of this study is the possibility that the BKT-LSTM model can significantly improve student performance and engagement in STEM programs.



## 1.6 Assumptions

The BKT-LSTM model deployed in this study does not factor in scenarios where there is cross-learning. Cross-learning is the term used to describe the scenario where the learning of one concept affects the learning of another concept. For example, in the real case scenario, there is a chance that the learning of the Java concept of inheritance requires prior knowledge of Java Classes. These cases have not been accounted for by the model in its task of learning the student performance patterns. The assumption being made here is that each problem in the quiz relates to one specific knowledge item. The knowledge items being tested in the study are:

1. Variables
2. Data
3. String I/O
4. Control Flow
5. Arrays
6. Classes

No tests have been conducted to ascertain the exact relationship between the individual knowledge items and the assumption states that the questions in the quiz relate to only the knowledge item in the list. A consequent assumption is that the student's learning of a knowledge item through the quiz questions does not affect the learning of another knowledge item in the same quiz or any other subsequent quizzes.

The study assumes that the students intend to learn the listed Java knowledge items through the revision in the quizzes. Naturally, another assumption is that the students are not guessing the answers blindly and that they are answering the questions through a logical stream of reasoning. The 3% extra credits that the students receive at the end of the study should not affect their response to the quiz questions and the engagement questions. Lastly, the study assumes that the student reports honest perception of engagement in the

engagement survey at the end of every quiz. Without these assumptions, the study could not have moved forward without factoring in for the modifications to negate the effects of the assumptions.

## 2. REVIEW OF LITERATURE

Intelligent Tutoring Systems (ITS) have proven to improve student learning [13], [14]. However, it is not widely used in educational settings because these systems are hard to design. One popular method to make designing the ITS systems easier is using available authoring tools which will help speed up the development of tutors. In recent times, many such authoring tools have been published [10], [15]–[18].

There are many different types of ITS already popularized:

1. Example tracing models
2. Conversational AI models
3. Statistical fill-the-hole models

Example tracing models rely on a previously recorded, expert imitation of the correct method of arriving at a solution to a given problem [19], [20]. These models help students by having them trace and imitate whatever the ITS is doing. Such models are not always suited for general STEM education applications, as example tracing is not suitable for teaching some high-level STEM concepts (such as Inheritance in Java).

Tutorial Dialog has been shown to be effective in supporting learners [21]. The model must be socially compatible in order to improve learning. Avis is a tutor with human-level social abilities that have achieved  $0.93\sigma$  learning effect compared to a model that had no human interaction capabilities [21]. Conversational AI models are relatively new in the field and rely on the power of the AI engine to help students by conducting almost human-like conversations with the end-users [2], [3]. Using an IBM-developed AI chatbot named iChat, conversational AI has been used to deliver vast amounts of knowledge content in education [22]. An Intent Interpretation Engine uses the user input to gauge the intent of the student to learn a specific knowledge item, consequently, the iChat Conversation Engine is activated to deliver content to students in a manner that resembles the classroom conversation between teachers and students.

Statistical fill-the-hole models rely on historic statistical data to predict the gap in the data that is coming in from the student’s input. By learning the patterns from the previous

data, the model will be able to predict the lacking regions in the data coming from the end-user in real-time [4]–[6]. The advance of neural networks has been highly beneficial to the study of ITS in an education setting because it speeds up the tutor development process significantly. Sequential learning has been greatly relevant to the advance of conversational AI systems (like chatbots) [23]–[26].

## **2.1 Findings pertaining to the problem and purpose**

### **2.1.1 BKT-LSTM**

The model we are proposing to train is the Bayesian Knowledge Tracing and Long Short-Term Memory model (BKT-LSTM)[12]. This model is proven to be effective in tutoring systems [12], which has boosted their popularity. The BKT-LSTM has three essential components:

1. Skill Mastery
2. Learning Transfer
3. Problem Difficulty

The idea is to train our neural network to predict student performance. In doing so, the ITS, in essence, will be reviewing those concepts that the students are having difficulty in by first giving them problems which are easier to complete and understand.

The input for the BKT-LSTM model requires:

- Student’s skill mastery: Probability of a student learning a skill
- Ability profile: The measure of learning transfer of a skill
- Problem difficulty: An integer value between 1 to 10 which quantifies the difficulty level of a problem

This model has proven to significantly boost the predictive performance of the ITS. The advantage of our model is due to two reasons:

1. Dynamic evaluation of student’s ability profile at each time interval

## 2. Dynamic evaluation of the problem difficulty at each time interval

Because of this, the BKT-LSTM will capture more variance in the input vector data and will consequently lead to better predictions at an individual student level [12].

### 2.1.2 Student Engagement

Student engagement can be defined as , "students' willingness, need, desire, and compulsion to participate in, and be successful in, the learning process" [27]. There is strong empirical evidence of a positive correlation between student engagement and learning outcomes in education [28]. The most commonly accepted broad types of engagement are as follows:

1. Behavioral engagement
2. Cognitive engagement
3. Emotional engagement

Behavioral engagement pertains to the student adhering to the rules of the class, engaging to completing the exercises, participating in giving feedback about the course and subject. Cognitive engagement includes how students overcome the tasks and challenges of the subject questions. This also involves looking into how much the student has invested into learning the concepts at hand and how it has affected the grades. Emotional engagement involves studying the student's perception of engagement about the learning achievements of the class.

Based on the analysis of Fredricks et al. [29], Figure 4 below explains the concept of measuring the three broad types of student engagement. To study the behavioral engagement, it is necessary to study the student's self-reported response about desiring to learn, participating in giving feedback about the class, perceived performance in the course, and confidence about the topics. This engagement will be evaluated through two channels.

1. Participation
2. Performance

The students' interaction time with the educational system can be an indicator of students' willingness to engage with the exercises [30]. Another scale of behavioral engagement is the student's willingness to participate in the study's development by asking questions and providing feedback [31].

To study performance-related engagement the information regarding the student's grades is needed. Additionally, students' self-reported answers to questions about perceived confidence can point to performance-related engagement scales [31].

Next is the measure of cognitive engagement, which pertains to those skills which the students have developed over the duration of the study. Moreover, the student's commitment to learning the materials regularly and staying up to date with the coursework is a good item to indicate relative cognitive engagement [31]. Additionally, the student's performance on higher-level problems can also be an indicator of the effort to learn.

The Achievement Emotions Questionnaire (AEQ) [32] is a very popular questionnaire developed to study the emotional engagement of students. There are three levels of student emotional engagement:

1. Class related emotions

- Enjoyment : Of being in the class
- Hope : Confidence about going to the class
- Pride : Pride about the taking the class

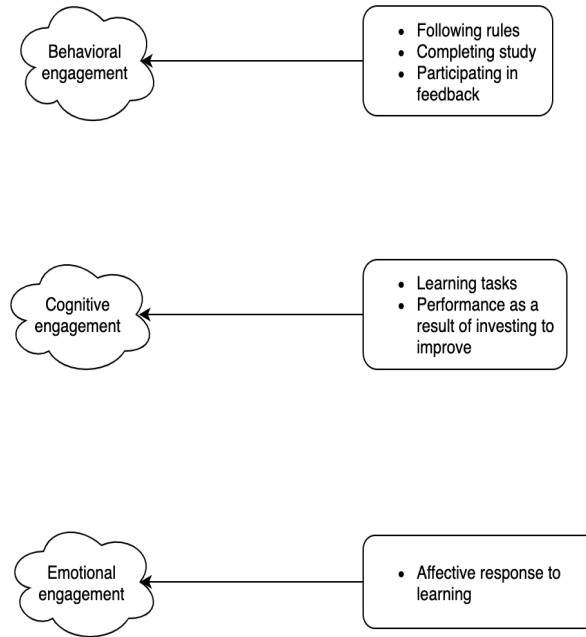
2. Learning relation emotions

- Enjoyment: Acquiring new knowledge
- Hope : Optimism about the class
- Pride: Capacity to learn

3. Test emotions

- Enjoyment: Enjoying the challenge
- Hope: Hope about abilities

- Pride: Pride about mastering the exercises



**Figure 2.1.** *Measuring engagement*

In the control-value theory, achievement emotions are defined as emotions directly tied to achievement activities [33]. Control-Value Theory tells us that success is posited to induce joy and contentment, and the non occurrence of expected success is posited to induce disappointment. The emotions pride and anger are thought to be control-dependent. These emotions are caused by causal features of success and failure implying that the self, other persons, or situational factors produced the achievement outcome. Pride and shame are posited to be induced by attributions of success and failure to the self, and gratitude and anger by attributions to other persons [33]. Students' perceived enjoyment of learning correlates positively with their flow experience and negatively with their task-irrelevant thinking at learning [33].

Based on these findings, the perception of engagement for the study are measured through two constructs:

1. Perceived enjoyment - Are the students feeling that they are enjoying the new quiz experience?

2. Perceived learning - Do the students feel like they are learning concepts by interacting with the new quiz setup?



### 3. METHODOLOGY

This section elaborates on the components of the BKT-LSTM model [34] and the corresponding design used to measure student perception of engagement.

#### 3.1 Introduction

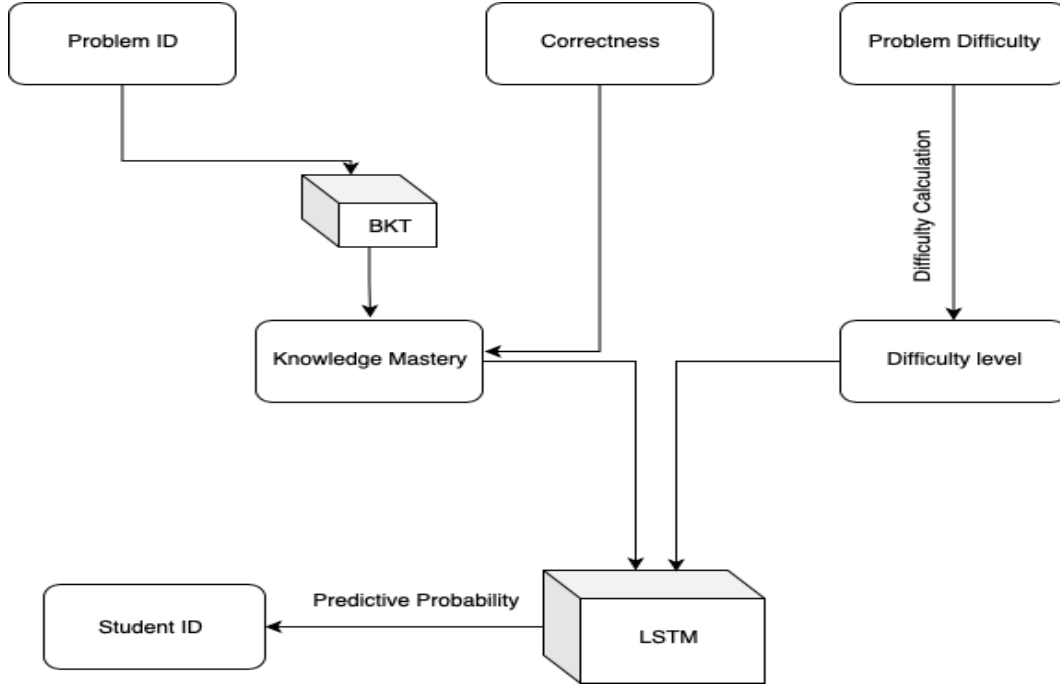
Inputs to the BKT-LSTM model require three features:

1. Skill Mastery
2. Learning Transfer
3. Problem Difficulty

In this section, the methodology of calculating these metrics are discussed and the methodology for the data collection is also presented.

#### 3.2 Research Approach

CNIT 25501 Introduction to Object Oriented Programming (in Java) will serve as the laboratory condition for our study. This course has weekly post-lecture quizzes (as explained in Section 2.4.1 in this document) which every student of the class must attempt and contributes to the course grade. We will use these quizzes to deploy our educational AI and measure its effects on the performance of the volunteering students.



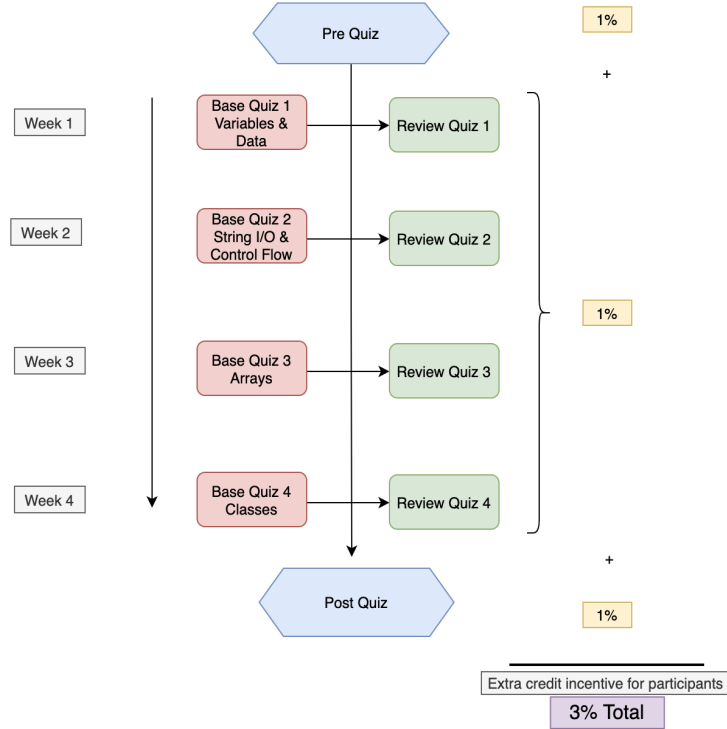
**Figure 3.1.** *The data flow map required to design the BKT-LSTM*

### 3.2.1 Design of Experiment

The experiment will be conducted in the classroom setting of the CNIT 25501 course. As this course has weekly quizzes which every student must attempt for grades, the volunteers for this experiment will be divided into control and experimental groups of equal sample size. While the class experience will remain unchanged for non-participants, each participant will be required to take extra quizzes every week as part of the study. Figure 2 shows the class calendar for CNIT 25501, based on the class syllabus, the experiment will include these knowledge areas:

1. Variables
2. Data
3. String I/O
4. Control Flow
5. Arrays

## 6. Classes



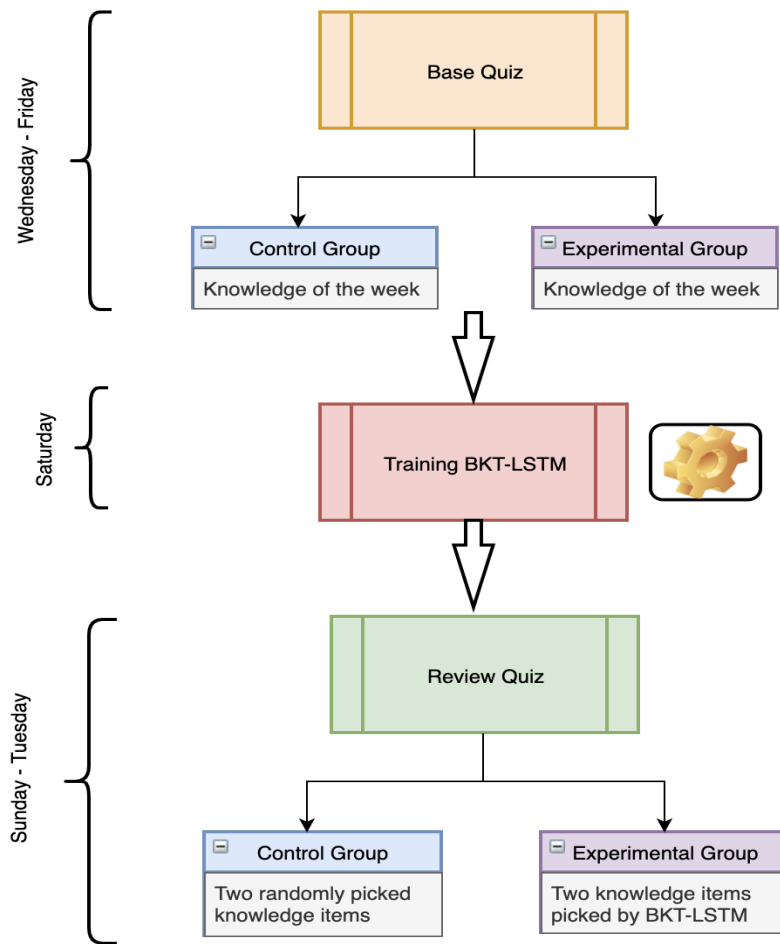
**Figure 3.2.** *Experiment setup in CNIT 25501*

At the beginning of the semester, an email announcement was sent out to all the students of the class explaining about the details of the study. The announcement entailed details about the study along with the 3% extra credit incentive that will be awarded to the participants. Figure 6 above shows the tentative 5-week plan for the study explaining about the knowledge areas being tested on and the extra credits for each week.

Participants took a common pre-quiz at the start of the course to assess baseline knowledge for members of both the control and the experiment groups. On completion of this pre-quiz, the students were awarded a 1% credit bonus. On completion of each of the consecutive weekly quizzes, they earn 1% more. This means that a student who completes the full study will be eligible to get a total of 3% extra credits on their grades for the course.

### 3.2.2 Weekly quizzes

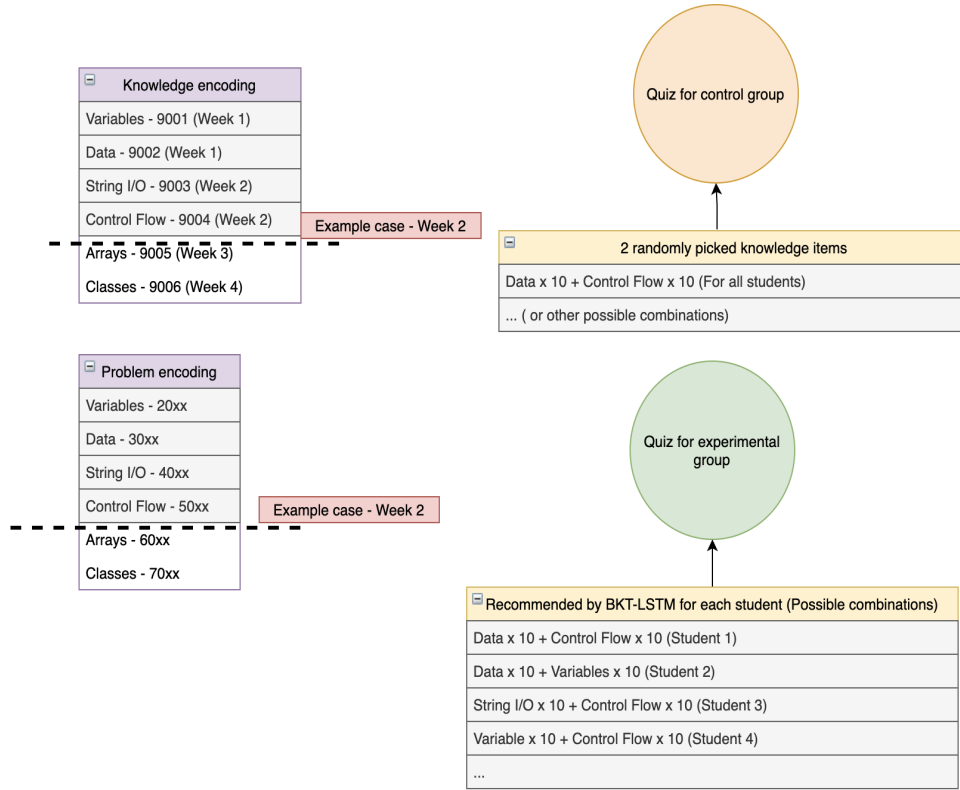
Figure 6 shows how the weeks were divided based on the knowledge areas being tested. A pre-quiz was given at the beginning of the semester to capture baseline student knowledge. Week one covered knowledge topics - Variables & Data. Week two covered String I/O & Control Flow. Week 3 covered Arrays, and week 4 covered Classes. At the end of these four weeks, a final quiz (Post-Quiz) was given to every participant. This final quiz tested the students on all that they had learned during the 5-week experimental course.



**Figure 3.3.** *Base Quiz and Review Quiz*

The base quiz is a quiz that is common to both the control and the experimental group, and it contains the topics taught in the class for the indicated week. The review quiz

configuration varies between the control and experimental group. The control group get questions from two knowledge items which were randomly picked. The experimental group gets questions from two knowledge items which were recommended by the BKT-LSTM model for each student.



**Figure 3.4.** Review Quiz week 2 example : Control group v/s the experimental group

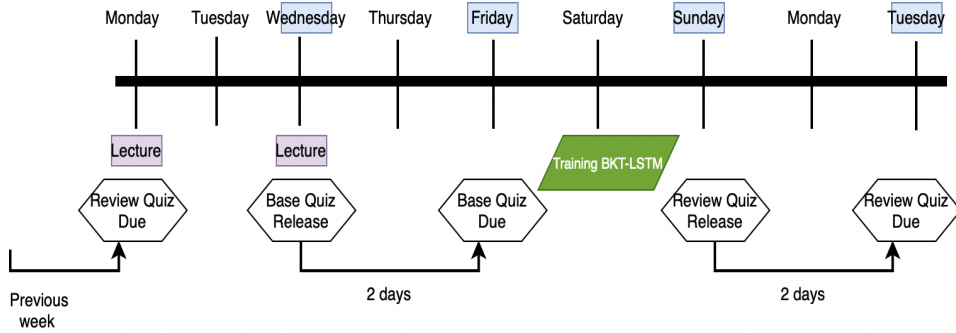
Figure 8 above shows how the experiment group and the control group differ in the kinds of questions that they will be expected to answer in the quizzes. Every quiz (for the control group as well as the experimental group) will have 20 questions each. As the Figure 8 shows, the control group was tested on the knowledge of the week whereas the students of the experimental group were tested on the knowledge of the week as well as the knowledge of the previous weeks for which the BKT-LSTM identified as lacking areas.

**Table 3.1.** *Sample data input table describing the variables*

Student ID	Knowledge	Problem ID	Problem Difficulty	Correctness
1001	String I/O	9520	5	1
1001	Arrays	9521	5	0
1002	String I/O	9520	5	0
...	...	...	...	...

### 3.2.3 Data Collection and Training

Sample data input appears in Table 1. In the assumptions described above, it is stated that we assume each knowledge component is independently learned and that the learning of one knowledge component does not affect the learning of the other. Table 1 shows the sample input for the BKT-LSTM training. Student ID, Knowledge ID, Problem ID, Problem Difficulty and Correctness are the variables required to train the model. Once the model is trained, it will be able to point out the lacking knowledge areas for each individual student. At the start of the semester, each problem is assigned a median (5) problem difficulty to initialize the model, and this value will be updated with each time interval based on the individual student performances.



**Figure 3.5.** *Data Collection - Weekly schedule*

### 3.3 Methodology - Measuring student engagement

The study plans to measure student engagement through two constructs: Perceived Learning and Perceived Enjoyment. The introduction of the BKT-LSTM educational model in a classroom causes changes in how students perceive the weekly-quizzes. The inherent methodology on which the BKT-LSTM constructs the customized questions means that every interacting student (participant in this case) is presented with different questions that vary based upon their unique learning patterns. As a result, two questions arise that help us understand the nature of change in the student's perception. The first question is: How does the student's perceived enjoyment while interacting with the BKT-LSTM vary compared to their response to traditional quizzes. It seeks to ask, do the students enjoy interacting with the proposed model of quizzes more than they enjoy interacting with traditional quiz models? Another question that can be posed is: How does the student's perceived learning level while interacting with the BKT-LSTM vary when compared to their response to traditional quizzes? In other words, do the students feel that they learn more when learning through the proposed model than when using the traditional quiz model?

Although other constructs may be considered such as those which dive deeper in exploring topics of perception of engagement, the study studies engagement through two constructs:

1. Perceived Enjoyment
2. Perceived Learning

To design the questionnaire, five questions were chosen and adapted to measure engagement through the two constructs. The following literature elaborates the particulars regarding the individual questions.

1. **Final adaptation:** The quiz experience makes me feel good
  - **Construct:** Perceived enjoyment
  - **Source questions:** The class experience makes me feel good [35]
2. **Final adaptation:** For me the quiz is a challenge that is enjoyable

- **Construct:** Perceived enjoyment
  - **Source questions:** For me the test is a challenge that is enjoyable [36]
3. **Final adaptation:** I am proud of how well I mastered the quiz
- **Construct:** Perceived learning
  - **Source questions:** I am proud of how well I mastered the exam [36]
4. **Final adaptation:** The quiz helps me remember the course material
- **Construct:** Perceived learning
  - **Source questions:** I can remember the course material [35]
5. **Final adaptation:** I feel like the quiz helps me learn the course topics
- **Construct:** Perceived learning
  - **Source questions:** I feel like I am learning topics covered in the course [35]

The two questionnaires that were chosen, Mazer [35] and Pekrun, R et al. (2011) [36] are both sturdy questionnaires. The scales of both questionnaires were tested via confirmatory factor analysis and the model produced a good fit and the engagement scales were proven to be reliable. The findings revealed that the statistics and reliability of the AEQ scales ranged from good to excellent. Ultimately, the scales were proven to be well suited to describe the internal structures of achievement emotions in terms of their affective, cognitive, motivational, and physiological components.

### 3.4 Questionnaire reliability

The questionnaires are internally divided into two parts for analysis - one for perceived enjoyment and one for perceived learning. The two questionnaires, although presented to the students as one questionnaire, were tested for reliability separately.



### 3.4.1 Perceived enjoyment

The perceived enjoyment questionnaire tested a Cronbach’s alpha value of **0.84**, a score considered to be good and shows that the scales are internally consistent and reliable to use.

### 3.4.2 Perceived learning

The perceived learning questionnaire resulted a Cronbach’s alpha score of **0.71**, a score considered to be an indicator of good reliability and one that indicates that the results are acceptable.

## 3.5 Response scoring

The final questionnaire developed to measure engagement contained five questions. Participants are asked to answer the questions by selecting any one of five answers and each choice of answer is assigned a unique numerical value. The scoring is based on a 5-point Likert Scale [37]:

1. Strongly Disagree (Value: 1 point)
2. Disagree (Value: 2 point)
3. Neutral (Value: 3 point)
4. Agree (Value: 4 point)
5. Strongly Agree (Value: 5 point)

## 3.6 Analysis

Hyperparameters used to initialize the BKT-LSTM model are:

1. lstm\_units = 100
2. batch\_size = 1
3. Number of epochs to train: epochs = 200

4. dropout\_rate = 0.2
5. Portion of data to be used to testing: test\_fraction=0.2
6. Portion of data to be used for validation validation\_fraction=0.2

### 3.6.1 Skill Mastery

To calculate the mastery of skills by individual students, the BKT-LSTM model requires a measure of four probabilities:

1.  $P(T)$ : The probability that a student who doesn't yet know the skill will learn the skill after the next immediate practice opportunity.
2.  $P(L_o)$ : The probability that the student already possesses the skill.
3.  $P(G)$ : The probability that the student who does not have the skill guesses the answer correctly.
4.  $P(S)$ : The probability that the student answers wrong despite possessing the skill.
5.  $P(C_t)$ : Probability that the student applying the skill correctly at given time  $t$ .
6.  $P(L_t)$ : The probability that the student knows the skill at a given time  $t$ .
7. 0 represents answers attempted incorrectly and 1 represents answers answered correctly.

$$P(L_t|1) = \frac{P(L_{t-1})(1 - P(S))}{P(L_{t-1})(1 - P(S)) + (1 - P(L_{t-1}))P(G)} \quad (3.1)$$

$$P(L_t|0) = \frac{P(L_{t-1})(P(S))}{P(L_{t-1})(P(S)) + (1 - P(L_{t-1}))(1 - P(G))} \quad (3.2)$$

$$P(L_t) = P(L_t|Action) + (1 - P(L_t|Action))P(T) \quad (3.3)$$

$$P(C_t) = P(L_{t-1})(1 - P(S)) + (1 - P(L_{t-1}))P(G) \quad (3.4)$$

Using these four equations we can finally arrive at the mastery level at time interval (t-1) which is the mastery level of the student before taking the practice questions.

$$P(L_{t-1}) = P(L_{t-1}|Action) + (1 - P(L_{t-1}|Action))P(T) \quad (3.5)$$

### 3.6.2 Learning Transfer

Transfer of learning is crucial to the process because it accounts for skills that are not independent. That is to say those skills that are usually used while employing other skills. Therefore, students use one skill to perform another skill to achieve their objectives.

1.  $R(x_j)_{1:z}$ : This is the success rate if the skill  $x_j$  being rightly answered at time interval t.
2.  $x_{jt}$ : The attempts of skill  $x_j$  being correctly answered at given time interval t.
3. n: Total number of all skills in the domain.
4.  $d_{1:z}^i$ : Performance vector for a student on all skills from the beginning time interval till interval z.

$$R(x_j)_{1:z} = \sum_{t=1}^z \frac{(x_{jt})}{|N_{jt}|} \quad (3.6)$$

$$d_{1:z}^i = (R(x_1)_{1:z}, R(x_2)_{1:z}, \dots, R(x_n)_{1:z}) \quad (3.7)$$

### 3.6.3 Calculating Problem Difficulty

As discussed, the problem difficulty is an integer value ranging from 1 to 10. Here is how it is calculated:

1.  $p_j$  : problem j

2.  $N_j$  : the set of all the students who answered problem  $p_j$
3.  $O_i(p_j)$  : A student  $i$  who answered problem  $p_j$ , this value is 1 if the answer is right, 0 otherwise.

$$p_j = \begin{cases} \delta(p_j), & \text{if } |N_j| \geq 4. \\ 5, & \text{otherwise.} \end{cases} \quad (3.8)$$

Where,

$$\delta(p_j) = modulo_{10}(\frac{\sum_i^{|N_j|} O_i(p_j)}{|N_j|}.10) \quad (3.9)$$

This way, the problem difficulty is calculated for each question based on the individual student answers. Note that the  $\delta(p_j)$  indicates the average correctness rate of problems. The resulting index value varies between 1 and 10, where a higher the index value indicates a higher presumed difficulty for a given problem  $p_j$ .

## 4. RESULTS

This section discusses the measurement of student perception of engagement. Missing data is filled by KNN imputation.

### 4.1 Population & Data Preprocessing

For the purpose of the study, participants were recruited to take a total of ten quizzes over the course of five weeks. A total of 38 students signed up for the study and they were divided randomly into two equal groups (19 each): one experimental group and one control group. Because the students were not enforced by rules to answer each of the ten quizzes, most of the quizzes were answered by only a partial percentage of the entire participant list. As a result, an average of 13.8 participants participated in every quiz in the experimental group, and an average of 15.4 participants participated in every quiz in the control group. This means that, on an average, only 14 of the 19 students in the experimental group participated per quiz, and 15 of the 19 students in the control group participated per quiz.

The general demographics varied across students, as 65% of the participants were Sophomores, 26% were Juniors, 6% were Seniors and the other 3% were Grad School students. All but 3% of the participants were from Purdue's Polytechnic Institute. The rest were from other departments at Purdue University. Further, the pre-semester programming experience across the participants also varied:

1. 50% reported Java as their primary programming language
2. 32% reported Python as their primary programming language
3. The rest 18% reported C#, C/C++ and other languages as their primary programming language.

Regarding general programming abilities:

1. 50% of the participants said they could write programs from scratch and debug most errors on their own.

2. 47% reported that they were beginners and could understand general syntax and write basic programs.
3. 3% reported to be advance level coders who can code multi-class programs which interact with GUIs, databases, and 3rd part software.

Regarding experience with Object Oriented Programming:

1. 56% reported to be beginners who have only just learnt about concepts of Object Oriented Programming
2. 35% reported intermediate level of experience with Object Oriented Programming - Can write code which employ concepts of Object Oriented Programming
3. 6% reported no prior knowledge or experience with Object Oriented Programming
4. Only 3% reported advance level of experience and could design and build complex multi code systems that rely on Object Oriented Programming concepts.

Out of the 38 participants who enrolled for the 5-week study, three participants did not attempt a single quiz. As no data-points exist for these three cases for extrapolation, the three participating students were dropped from the data set while performing the data preprocessing. Also, 42% of the remaining entries had missing values, which meant that 42% of the students did not complete all the ten quizzes, completing only a few of them over the course of the experiment.

For those with missing values, k-nearest neighbor algorithm (kNN) was used to impute multiple values. When compared with other multiple imputation methods to handle missing values, kNN turned out to be the most effective in maintaining the consistency of our data.

## 4.2 Results

The individual construct values were plotted on a histogram and it was verified that the values followed a normal distribution needed for the t-tests.

### 4.2.1 Perceived Enjoyment

The overall data for the perceived enjoyment response reported a mean of  $M=3.37$  and a standard deviation of  $SD=.87$ . The experimental group reported  $M=3.3$  and  $SD=.87$ . The control group reported  $M = 3.43$  and  $SD=.71$ . The data was subjected to an independent t-test between the two groups and between the individual tests. The data reported the following results.

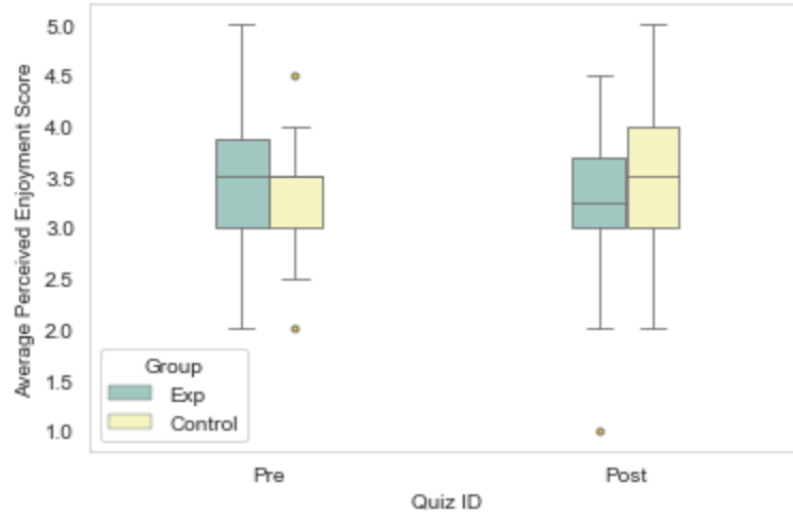
In the Pre-quiz, no significant difference was reported between the experimental group ( $M=3.33$ ,  $SD=.87$ ) and the control group ( $M=3.30$ ,  $SD=.58$ ),  $t(33)=0.10$ ,  $p=.92$ ;  $d=0.03$ . This is expected, as the pre-quiz measured the baseline knowledge between the two groups. The results show that the perceived enjoyment among members of the two groups were roughly equal.

In the first base quiz (B1), the control group scored similar perceived enjoyment level ( $M=3.30$ ,  $SD=0.58$ ) as the experimental group ( $M=3.33$ ,  $SD=0.93$ ),  $t(33)=-0.28$ ,  $p=.78$ ;  $d=-0.09$ , with no significant results being reported by the t-test. In the second base quiz (B2), no significant difference was observed between the two groups, even with the control group showing higher scores ( $M=3.61$ ,  $SD=0.69$ ) than the experimental group ( $M=3.36$ ,  $SD=0.85$ ),  $t(33)=-0.97$ ,  $p=.33$ ;  $d=-0.32$ . In the third base quiz (B3), again we see the control group ( $M=3.55$ ,  $SD=0.72$ ) scoring higher than the experimental group ( $M=3.20$ ,  $SD=0.98$ ) by a larger margin,  $t(33)=-1.08$ ,  $p=.28$ ;  $d=-0.37$ , but the differences turned out to be insignificant. In the last base quiz (B4), it is observed that although the gap reduced compared to B3, the control group ( $M=3.1$ ,  $SD=0.88$ ) reported higher perceived enjoyment levels than the experimental group ( $M=3.33$ ,  $SD=0.86$ ) but the difference is not conclusive as they are insignificant,  $t(33)=-0.57$ ,  $p=.57$ ;  $d=-0.19$ . None of the t-test results reported significant differences ( $p<0.05$ ).

In the first review quiz (R1), although the control group ( $M=3.5$ ,  $SD=0.74$ ) scores higher, the difference between the two groups is insignificant,  $t(33)=-0.32$ ,  $p=.74$ ;  $d=-0.11$ . In the second review quiz (R2), a reversal in the trend is observed with the experimental group ( $M=3.37$ ,  $SD=0.83$ ) reporting much higher values of perceived enjoyment than the control group ( $M=3.14$ ,  $SD=0.74$ ), but the t-test showed no significant difference between the

two groups,  $t(33)=0.85$ ,  $p=.40$ ;  $d=0.28$ . In the third review quiz, the trend reverses yet again but the difference between the two groups is insignificant, with the control group ( $M=3.36$ ,  $SD=0.72$ ) scoring slightly higher than the experimental group ( $M=3.33$ ,  $SD=1.02$ ),  $t(33)=-0.18$ ,  $p=.85$ ;  $d=-0.06$ . In the final review quiz (R4), no significant difference is observed between the control group ( $M=3.48$ ,  $SD=0.67$ ) and the experimental group ( $M=3.15$ ,  $SD=0.88$ ),  $t(33)=-1.25$ ,  $p=.21$ ;  $d=-0.42$ . It is important to note that none of the t-tests yielded significant p values ( $p<0.05$ ).

In the final quiz, Post-quiz, the control group ( $M=3.42$ ,  $SD=0.72$ ) and the experimental group ( $M=3.19$ ,  $SD=0.84$ ) show no significant difference in their opinions,  $t(33)=-0.86$ ,  $p=.39$ ;  $d=-0.29$ .



**Figure 4.1.** *Box plot of perceived enjoyment response scores between the groups in the Pre and Post quizzes*

#### 4.2.2 Perceived Learning

The overall data for the perceived learning response reported a mean of  $M=3.47$  and a standard deviation of  $SD=0.66$ . The experimental group reported  $M=3.43$  and  $SD=.73$ . The control group reported  $M=3.43$  and  $SD=.56$ . The data was subjected to an independent t-test between the two groups and between the individual tests and the data reported the following results.



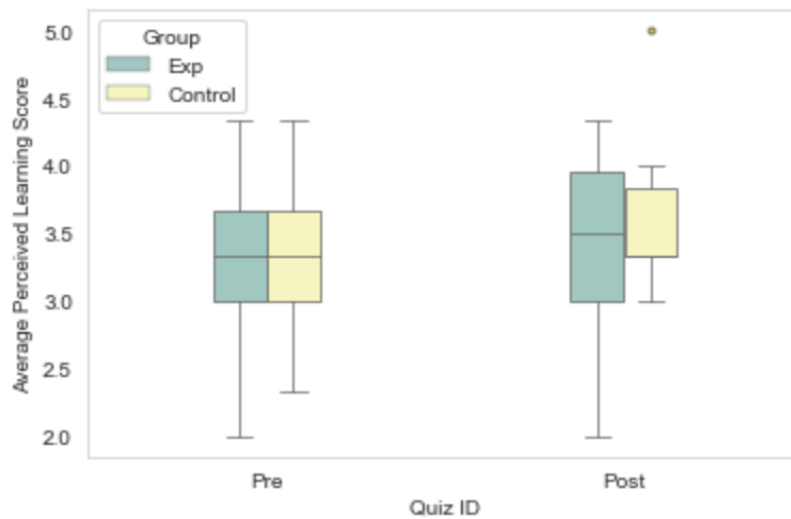
In the Pre-quiz, the two groups, the experimental group ( $M=3.26$ ,  $SD=0.62$ ), and the control group ( $M=3.31$ ,  $SD=0.47$ ), appear to agree on the same score and show no statistically significant difference,  $t(33)=-0.23$ ,  $p=.81$ ;  $d=-0.08$ . The Pre-quiz measures the baseline knowledge of the participants, and the results of the common test shows that the groups began on an equal perception of engagement footing in terms of perceived learning.

Two insights can be derived from the participant responses of perceived learning levels. First, the t-test reveals that both the groups agree on same perceived learning with the control group ( $M=3.70$ ,  $SD=0.62$ ) showing no significant difference with the experimental group ( $M=3.64$ ,  $SD=0.84$ ),  $t(33)=-0.23$ ,  $p=.81$ ;  $d=-0.07$ . Secondly, the observed response is close, if not very similar, to the response observed in the Pre-quiz. The base quiz and the Pre-quiz are both common quizzes, and the students naturally appear to agree on the same perception of engagement response. The second base quiz (B2), the control group ( $M=3.61$ ,  $SD=0.55$ ) reported no significant difference in perceived learning with the experimental group ( $M=3.64$ ,  $SD=0.82$ ),  $t(33)=-1.0$ ,  $p=.32$ ;  $d=-0.34$ . The third base quiz (B3) again shows no significant difference between the groups, with the control group ( $M=3.72$ ,  $SD=0.59$ ) scoring nearly 3.7 which, when rounded up, translates to ‘Agree’ on the Likert Scale, and the experimental group ( $M=3.79$ ,  $SD=0.83$ ) scoring nearly 3.4 which, when rounded down, translates to ‘Neutral’ on the same scale,  $t(33)=-1.4$ ,  $p=0.16$ ;  $d=-0.47$ . In the final base quiz (B4), the control group again showed no significant difference ( $M=3.50$ ,  $SD=0.72$ ) with the experimental group ( $M=3.39$ ,  $SD=0.75$ ),  $t(33)=-0.44$ ,  $p=0.66$ ;  $d=-0.15$ .

In the first review quiz (R1), both the control group ( $M=3.56$ ,  $SD=0.52$ ) and the experimental group ( $M=3.50$ ,  $SD=0.73$ ) reported ‘Agree’ to perceived learning on the Likert Scale,  $t(33)=-0.31$ ,  $p=.75$ ;  $d=-0.10$  and no significant difference was reported between the groups. In the second review quiz (R2) where the control group ( $M=3.46$ ,  $SD=0.40$ ) staying steady on the previous response in contrast with the experimental group ( $M=3.31$ ,  $SD=0.68$ ) that changes the response to a ‘Neutral’,  $t(33)=-0.76$ ,  $p=.45$ ;  $d=-0.25$ , but no significant difference was observed between the two groups. In the third review quiz (R3), a lot more people in the control group ( $M=3.75$ ,  $SD=0.59$ ) appear to have reported to ‘Strongly Agree’ resulting in the sharp increase in the score when compared to the experimental group ( $M=3.30$ ,  $SD=0.68$ ), which appears to remain ‘Neutral’ on the Likert Scale,  $t(33)=-2.18$ ,  $p=.03$ ;  $d=-$

0.73. The p value ( $p < 0.05$ ) shows that the difference between the group was significant. In the last review quiz (R4), where the control group ( $M=3.49$ ,  $SD=0.62$ ) reported to again have agreed on the Likert Scale, whereas the experimental group ( $M=3.15$ ,  $SD=0.80$ ) remains neutral, no significant difference was observed between the groups,  $t(33)=-1.36$ ,  $p=.18$ ;  $d=-0.46$ .

In the final quiz, the Post-quiz, the control group ( $M=3.55$ ,  $SD=0.51$ ) and the experimental group ( $M=3.42$ ,  $SD=0.64$ ) show no significant difference,  $t(33)=-0.66$ ,  $p=.50$ ;  $d=-0.22$ . Significant results were observed only in Review quiz 3 (R3) and no other t-test between the different quizzes revealed significant difference.



**Figure 4.2.** *Box plot of perceived learning response scores between the groups in the Pre and Post quizzes*

## 5. DISCUSSION

### 5.1 Interpretation of Results

Although not all the quizzes revealed significant differences in the t-tests, some insight can be derived by observing the variation in the responses as the quizzes progressed. Regarding perceived enjoyment, Figure 12(a) shows how the responses varied between the groups in the 5-week period. A significant difference was observed in the student response to perceived learning in the second review quiz (R2) which focused on two critical knowledge areas – of Variables and Control Flow.

Although the control group agreed to perceive enjoyment more frequently than the experimental group, one can observe from Figure 13(a) that the two groups stay roughly below a score of 3.5. This, when rounded, translates to a ‘Neutral’ perceived enjoyment on the Likert Scale. The data suggests an answer to the first research question (RQ1), Do the students perceive more enjoyment while interacting with the BKT-LSTM than those interacting with traditional educational models? We can say that the two groups showed no significant difference in response. Both the groups observed a neutral perception of engagement to having perceived enjoyment. The comparison between the Pre-quiz and the Post-quiz in Figure 14(a) further confirms the assertion that the two groups showed no significant difference in the end. Additionally, the correlation between engagement and learning performance can be a topic for future analysis [7]

Regarding perceived learning, the two groups once again started with an equal outlook when asked about the perception of learning. Both the Pre-quiz and the first base quiz (B1) observe close agreement between the two groups. Figure 12(b) shows the variation in the student perceived learning responses over the 5-week study period. With both groups agreeing to a ‘Neutral’ response on the first quiz, the two groups jointly ‘Agree’ to the perception of learning by the time the second base quiz (B2) is completed. Figure 13(b) makes the observation clearer with the comparison set at the review quiz level. The review quizzes constantly made the participants in the control group feel that they learned some new knowledge as opposed to the experimental group that does not enthusiastically agree

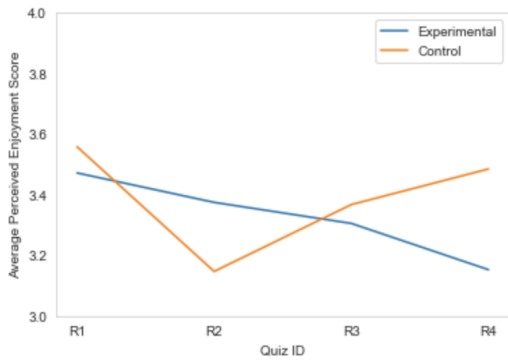


(a) Perceived Enjoyment

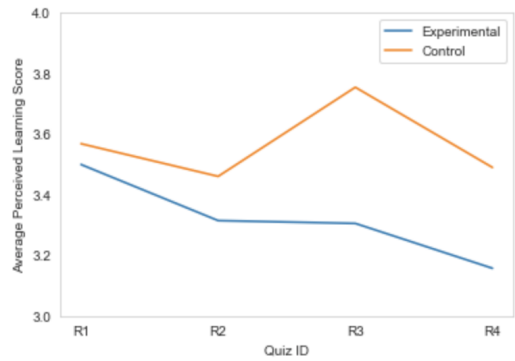


(b) Perceived Learning

**Figure 5.1.** Response curve of the two groups over the course of the 10-quiz study to the two different constructs used to measure student engagement

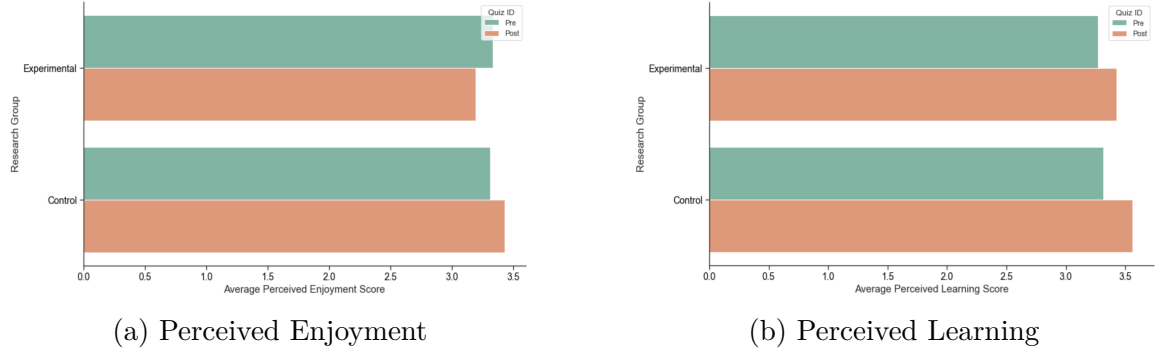


(a) Perceived Enjoyment



(b) Perceived Learning

**Figure 5.2.** Response curve of the two groups in the review quizzes to the two different constructs used to measure student engagement



**Figure 5.3.** *Difference in the response between the groups in the Pre-Quiz and the Post-Quiz*

on that prospect, but no conclusive insights can be drawn from the observation because the data showed no significant difference between the groups.

Based on the data, an insight to answer the second research question (RQ2) can be derived; Do the students perceive more learning while interacting with the BKT-LSTM than those interacting with traditional educational models? The control group reported more frequently to have perceived learning than the experimental group. But because the data showed no significant difference in the t-tests, no conclusive insights can be drawn from the observations. Both the groups maintained a neutral opinion of perceived learning. In future studies, each condition can be split into high-performing and low-performing groups to study the differences in results over time between the groups.

## 5.2 Broader Impacts

Studies have shown that the biggest perceived advantage of integrating a simulation model practice in engineering education is the opportunity for students to solve real-world problems in a classroom setting [38]. Teachers should work together to form teams and build technology systems. The system will benefit if it implements these four critical characteristics: Pedagogical Core, Emergent Use, Community Building, and Research-Based [39]. Teachers who use simulated practices find it useful while teaching-related topics to students [38]. Computational tools act as bridges connecting the fundamental principles and the engineering practices. And although the existing studies have barely yielded conclusive results,

students generally agree that computational tools are useful for their learning [39]. There are a wide variety of intended learning goals that the instructor can aim for while implementing computational simulations as learning tools. Models can be used to introduce the students about its existence in the field. It can be used to help students implement computational techniques. Or help students predict results of an experiment in a design task. Crucially, models are used to teach students how to discriminate models to represent a given phenomenon [40].

Newer methods to improve the BKT-LSTM model through regression can be explored in future iterations [41], [42]. Computational modeling allows educators to address gaps in both thinking and existing curriculum. Existing definitions of computational thinking need to be refined and standardized in order to pave the way for future developments in this field. A core competency of such a system in engineering education is modeling and simulation activities [43]. This presents a huge potential for future research in this field.

BKT-LSTM as applied to engagement might also be applicable outside of classroom environments. For example, other important contexts in which BKT-LSTM could be empirically tested to determine its effect on engagement include virtual programming environments [44], [45], serious games [46]–[48], and virtual reality and learning [49]–[51]. Environments that are entertainment-oriented but include a learning component (such as tutorials or learning interaction mechanics) may also be areas where BKT-LSTM could be applied, e.g., games [52]–[54] and game-making [55].

### 5.3 Limitations

A significant flaw in the study arises from the unimplemented participant feedback system. The feedback system provides participating students, after they complete the respective quiz, with the right answers to the wrongly answered questions. This would have helped the participating students of both the groups in improving their learning. Ultimately, the system was not put into use while the study took place.

Another evident limitation in the study is the number of participants who completed the quizzes. As seen before, only 14 people on average took the quizzes out of the 19 people

in the experimental group. Further, only 15 people took the quizzes in the control group. Not only this, but inconsistencies appeared across individual students, some of whom took a base quiz but never completed any of the review quizzes. A few students did attempt at least one quiz over the 5-week duration. This may be the source of observed inconsistencies in the results and the analysis. With a total of 38 students registered as volunteers, the size of the participant list presents another limitation of this study. Any study that relies on numerical data must have a high sampling population to produce an accurate representation of facts. The third source of concern is that some of the students who had completed the quizzes did so in a hurried manner, as was suggested by the ‘time-to-complete’ variable which measured the students elapsed time when attempting the quizzes. Some of the quizzes were completed in under two minutes or less. A quiz such as the ones deployed in the study, with 20 questions of Java and Object Oriented Programming based items, simply cannot naturally be completed in such a short period of time unless it was done so without putting any effort, and by simply guessing the answers. Naturally, the data points collected from such events will skew results.

Although the pre-quiz score did not significantly differ between the control and the experimental groups, the possibility that there could have still been some difference that affected the results was not considered. In the study, the pre-quiz was not considered as a covariate that affects group performance. In future studies, the pre-quiz can be considered an independent variable to better understand its effects on the results. Additionally, the base quiz was closer to the class lectures than the review quiz. While the class lectures were fresh in the minds of the students when they attempted the base quizzes, it wasn’t so during the review quizzes. This might have had an effect on the learning performance of students. Future studies can factor this possibility for analyses.

## 6. CONCLUSION

Although very few of the t-tests revealed a significant difference between the control and the experimental group, the study shows that both the groups roughly remained neutral to the perception of engagement of enjoyment while taking the quizzes. The same can be said about the perceived learning, the two groups showed no major differences. However, the control group reported to strongly agree to perceived learning in the third review quiz (R3) when compared to the experimental group which remained neutral about the perception of engagement. A significant difference was observed in the responses of the two groups in the third review quiz.

Another observation that came to light was that very few participants reported disagreements with any of the two engagement constructs. When considered from this perspective, the neutral response of the experimental group can be thought of as an indicator that the BKT-LSTM had a non-detrimental effect when introduced in a live STEM classroom. This calls for further development of the model. The BKT-LSTM method shows promise in its effectiveness to individually cater to students' needs. Future work will focus on training with large data sets distributed over diverse time frames. The model learns better when trained with large data sets containing sufficient data points for each student.



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## A. APPENDIX FOR ENGAGEMENT

Contains engagement questions used to evaluate student engagement through two constructs - perceived learning and perceived enjoyment.

### 1. The quiz experience makes me feel good (Construct: Perceived Enjoyment)

**Original question:** *The class experience makes me feel good*

**Source:** Mazer, J. P. (2012). Development and Validation of the Student Interest and Engagement Scales. *Communication Methods and Measures*, 6(2), 99–125. <https://doi.org/10.1080/19312458.2012.679244>

- A. Strongly Agree
- B. Agree
- C. Neutral
- D. Disagree
- E. Strongly Disagree

### 2. For me the quiz is a challenge that is enjoyable (Construct: Perceived Enjoyment)

**Original question:** *For me, the test is a challenge that is enjoyable*

**Source:** Pekrun, R., Goetz, T., Frenzel, A. C., Barchfeld, P., & Perry, R. P. (2011). Measuring emotions in students' learning and performance: The Achievement Emotions Questionnaire (AEQ). *Contemporary Educational Psychology*, 36(1), 36–48. <https://doi.org/10.1016/j.cedpsych.2010.10.002>

- A. Strongly Agree
- B. Agree
- C. Neutral
- D. Disagree
- E. Strongly Disagree

### 3. I am proud of how well I mastered the quiz (Construct: Perceived Learning)

**Original question:** *I am proud of how well I mastered the exam*

**Source:** Pekrun, R., Goetz, T., Frenzel, A. C., Barchfeld, P., & Perry, R. P. (2011). Measuring emotions in students' learning and performance: The Achievement Emotions Questionnaire (AEQ). *Contemporary Educational Psychology*, 36(1), 36–48. <https://doi.org/10.1016/j.cedpsych.2010.10.002>

- A. Strongly Agree
- B. Agree
- C. Neutral
- D. Disagree
- E. Strongly Disagree

4. The quiz helps me remember the course material (Construct: Perceived Learning)

**Original question:** *I can remember the course material*

Source: Mazer, J. P. (2012). Development and Validation of the Student Interest and Engagement Scales. Communication Methods and Measures, 6(2), 99–125. <https://doi.org/10.1080/19312458.2012.679244>

- A. Strongly Agree
- B. Agree
- C. Neutral
- D. Disagree
- E. Strongly Disagree

5. I feel like the quiz helps me learn the course topics (Construct: Perceived Learning)

**Original question:** *I feel like I am learning topics covered in the course*

Source: Mazer, J. P. (2012). Development and Validation of the Student Interest and Engagement Scales. Communication Methods and Measures, 6(2), 99–125. <https://doi.org/10.1080/19312458.2012.679244>

- A. Strongly Agree
- B. Agree
- C. Neutral
- D. Disagree
- E. Strongly Disagree

## B. APPENDIX FOR QUESTION BANK

Appendix A includes the questions bank for the five selected pieces of knowledge (Variables/Data, String I/O, Control flow, Array, and Classes). The question bank includes 140 self-developed questions and 106 adapted questions from publicly available question banks<sup>1 2</sup>. All the questions were validated by an experienced Java expert. Correct answers were marked red.

### B.1 Variables/Data

(2001) Self-developed

1) What is the correct method to declare a variable of type Integer in Java?

- a) **int variable\_name;**
- b) variable\_name int;
- c) Int variable\_name;
- d) Integer variable\_name;

(2002) Self-developed

2) Pick the correct way to assign a value to a variable:

- a) value = variable\_name;
- b) value variable\_name;
- c) **variable\_name = value;**
- d) variable\_name == value;

(2003) Self-developed

3) In Java it is possible to declare and initialize a variable with a one-line code, pick the option with the incorrect syntax:

- a) int number = 1;
- b) boolean flag = true;
- c) String name = "CNIT25501";
- d) **int number == 1;**

(2004) Self-developed

4) Which of the following is NOT a primitive data type in Java?

- a) short
- b) byte
- c) long
- d) **String**

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<sup>1</sup>↑“JAVA programming final exam questions”, [Online]. Available:

<https://wenku.baidu.com/view/5010c983c67da26925c52cc58bd63186bdeb9245.html> [Accessed:30-Jun-2021].

<sup>2</sup>↑“JAVA programming final exam questions and answers”, [Online]. Available:

[https://wenku.baidu.com/view/8c6903d48f9951e79b89680203d8ce2f006665ed.html?rec\\_flag=default&fr=pc\\_newview\\_relate1001\\_12wk\\_rec\\_doc1001\\_138c6903d48f9951e79b89680203d8ce2f006665ed&xsxts1624534888041](https://wenku.baidu.com/view/8c6903d48f9951e79b89680203d8ce2f006665ed.html?rec_flag=default&fr=pc_newview_relate1001_12wk_rec_doc1001_138c6903d48f9951e79b89680203d8ce2f006665ed&xsxts1624534888041) [Accessed:30-Jun-2021].



(2005) Self-developed

- 5) What is the default value of an instance variable of type boolean?
- a) true
  - b) false
  - c) null
  - d) 0

(2006) Self-developed

- 6) It is possible to convert an integer value into a boolean value.
- a) True
  - b) False

(2007) Self-developed

- 7) A reference variable contains a reference to an object.
- a) True
  - b) False

(2008) Self-developed

- 8) Which of the following type conversions are NOT automatic in Java?
- a) int => double
  - b) char => int
  - c) double => short
  - d) float => double

(2009) Self-developed

- 9) In Java n+=4; is the same as n = n + 4;
- a) True
  - b) False

(2010) Self-developed

- 10) Pick the right method to use the increment operator:
- a) variable\_name++;
  - b) ++variable\_name;
  - c) variable\_name+;
  - d) +variable\_name;

(2011) Self-developed

- 11) What is the output of the following code?

```
public static void main(String[] args)
{
    double a = 10.5 % 2;
    double b = 10.5 / 2;
    double c = 10.5 * 2;
    System.out.print(a);
    System.out.print(b);
    System.out.print(c);
}
```

- a) 0.5 5.25 21.0
- b) 10 5.25 21
- c) 10.5 5 21.0
- d) 0.5 5.25 21

(2012) Self-developed

12) In this code, args is considered to be a/an,

```
public static void main(String[] args){  
    //some code;  
}
```

- a) Class
- b) Constant
- c) Integer
- d) Array

(2013) Self-developed

13) Given the following code snippet:

```
public static void main(String[] args){  
    int a = 5;  
    int b = 7;  
    int c = a*b;  
    double c = a*b;  
    System.out.println(c);  
}
```

What will be printed?

- a) 35
- b) 35.0
- c) "5\*7"
- d) No Output

(2014) Adapted from Q4, page 5 in "《JAVA Programming》Final Exam Questions and Answers", 2019, Baidu Library [2]

Original: 以下哪个不是Java的原始数据类型?

(Which of the following is NOT a primitive data type in Java?)

- a) int
- b) Boolean
- c) float
- d) char

14) Which of the following is NOT a primitive data type in Java?

- a) int
- b) double
- c) byte
- d) long int

(2015) Adapted from Q2, page 16 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: 下列 \_\_\_\_ 是Java合法的标识符

(The following \_\_\_\_ is a valid identifier in Java)

- a) static
- b) 5stu
- c) -3e
- d) \_atm

15) Which of the following is NOT a valid identifier in Java?

- a) \$var
- b) \_pop
- c) new
- d) stu1

(2016) Self-developed

16) Which of the following is the correct way for adding Java annotation?

- a) /\* I love CNIT 25501 \*/
- b) // I love CNIT 25501 \*/
- c) /\*\* I love CNIT 25501 \*/
- d) /\* I love CNIT 25501 \*\*/

(2017) Adapted from Q2, page 16 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]  
Original: the same with problem 2015

17) Which of the following is NOT a valid identifier in Java?

- a) STRING
- b) INT
- c) de\_\$f123
- d) void

(2018) Self-developed

18) Given the following Java code snippet:

```
public static void main(String[] args){
    int a = 8;
    int b = 3;
    int c = a / b;
    double c = a / b;
    System.out.println(c);
}
```

What will be printed?

- a) 2.666666...
- b) 2
- c) 2.6
- d) 2.0

(2019) Self-developed

19) Which of the following is correct for initializing a boolean variable?

- a) boolean a = 1;
- b) boolean a = ("a" > "z");
- c) boolean a = "False";
- d) boolean a == 1;

(2020) Adapted from Q4, page 23 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: 下列程序运行后，输出的结果是 \_\_\_\_

(Given the following Java code snippet, the output is \_\_\_\_)

```
public static void main(String args[]) {
    int c = 5;
    System.out.print(c);
    System.out.print(c++);
    System.out.print(c);
}
```

20) What is the output of the following Java code snippet?

```
public static void main(String args[]) {
    int a = 10;
    System.out.print(a--);
    System.out.print(a++);
    System.out.print(a);
}
```

- a) 91010
- b) 101010
- c) 91111
- d) 91110

(2021) Self-developed

21) Which of the following is the correct operator priority?

- a) "(" > "!" > "=" > "+" > "&&"
- b) "(" > "!" > "+" > "&&" > "="
- c) "(" > "+" > "=" > "!" > "&&"
- d) "(" > "+" > "&&" > "!" > "="

(2022) Self-developed

22) Which of the following is the correct method to declare a variable?

- a) float f = 1.1
- b) double d = 34.4
- c) int i = 4L
- d) char a = int(1.12)

(2023) Self-developed

23) We can change the value of a **final** variable

- a) True
- b) False

(2024) Adapted from Q1, page 16 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: 下列关于java语言的叙述中, 正确的是 \_\_\_\_

(Which of the following is TRUE about Java \_\_\_\_)

- a) 机器语言 (machine language)
- b) 汇编语言 (assembly language)
- c) 面向过程的语言 (process-oriented programming language)
- d) 面向对象的语言 (object-oriented programming language)

24) Which of the following is TRUE about Java?

- a) Java is a machine language
- b) Java is an assembly language
- c) Java is an object-oriented programming language
- d) Java is a process-oriented programming language

(2025) Adapted from Q7, page 16 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: 执行下列程序段后, b, x, y的值正确的是 \_\_\_\_

(Given the following Java code snippet, the values of b, x, y is \_\_\_\_)

```
int x = 6;
int y = 8;
boolean b = x < y || ++x == --y;
```

- a) true, 6, 8
- b) false, 7, 7
- c) true, 7, 7
- d) false, 6, 8

25) Given the following Java code snippet:

```
int x = 12;
int y = 11;
boolean b = (x < y || --x == y);
```

What is the value of the variables b, x, and y, respectively?

- a) true, 12, 11
- b) true, 11, 11
- c) false, 11, 11
- d) false, 12, 10

(2026) Adapted from Q7, page 16 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: the same with 2025

26) Given the following Java code snippet:

```
int x = 6;
int y = 8;
boolean b = (x < y || x++ == y);
```

What is the value of the variables b, x, and y, respectively?

- a) true, 6, 8
- b) true, 7, 8
- c) false, 6, 8
- d) false, 7, 8

(2027) Adapted from Q7, page 16 in "JAVA programming final exam questions", 2017, Baidu Library [1]  
Original: the same with 2025

27) Given the following Java code snippet:

```
int x = 6;
int y = 8;
boolean b = (x < y && x++ == y);
```

What is the value of the variables b, x, and y, respectively?

- a) true, 6, 8
- b) true, 7, 8
- c) false, 6, 8
- d) false 7, 8

(2028) Adapted from Q7, page 16 in "JAVA programming final exam questions", 2017, Baidu Library [1]  
Original: the same with 2025

28) Given the following Java code snippet:

```
int x = 6;
int y = 8;
boolean b = (x < y && ++x == --y);
```

What is the value of the variables b, x, and y, respectively?

- a) true, 6, 8
- b) true, 7, 7
- c) false, 6, 8
- d) false, 7, 7

(2029) Adapted from Q7, page 16 in "JAVA programming final exam questions", 2017, Baidu Library [1]  
Original: the same with 2025

29) Given the following Java code snippet:

```
int x = 6;
int y = 8;
boolean b = (x < y || ++x == --y);
```

What is the value of the variables b, x, and y, respectively?

- a) true, 6, 8
- b) true, 7, 7

(2030) Adapted from Q11, page 16 in "JAVA programming final exam questions", 2017, Baidu Library [1]  
Original: 以下关于Java程序叙述正确的是 \_\_\_\_  
(Which of the following statements is TRUE)

- a) Java程序中main函数必须位于最前  
(In a Java program, the main method must be at the front of all the methods)
- b) Java程序每行只能有一条语句  
(In a Java program, there can only be one statement per line)
- c) 在对一个Java程序的编译过程中, 可以发现注释的错误  
(In a Java program, we can detect the errors in the annotation when compiling)
- d) Java程序必须有一个主函数  
(In a Java, program, there must be the main method)

30) Which of the following statements is TRUE?

- a) In a Java program, there can only be one statement per line
- b) In a Java, program, there must be the main method
- c) In a Java program, the main method must be at the front of all the methods
- d) In a Java program, we can detect the errors in the annotation when compiling

(2031) Self-developed

31) Given the following Java code snippet:

```
int a = 1;
int b = 1;
boolean m = (a++ > b);
```

What is the value of a and m, respectively?

- a) 1, true
- b) 2, true
- c) 1, false
- d) 2, false

(2032) Self-developed

32) Given the following Java code snippet:

```
int a = 1;
int b = 1;
boolean m = (++a > b);
```

What is the value of a and m, respectively?

- a) 1, true
- b) 2, true
- c) 1, false
- d) 2, false

(2033) Self-developed

33) What is the data type of the expression  $8 / 9.2 * 5$ ?

- a) short
- b) int
- c) double
- d) float

(2034) Self-developed

34) Given the following Java code snippet:

```
int a = 8;
int b = 4;
double c = a / b;
```

What is the value of the variable c?

- a) 2
- b) 2.0
- c) 4.0
- d) 8

(2035) Self-developed

35) Which of the following is NOT the correct variable declaration?

- a) double d = 545;
- b) char c = "a";
- c) int i = 321;
- d) float f = 4.0;

(2036) Translated from Q56, page 21 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: 设  $x = 1$ ,  $y = 2$ ,  $z = 3$ , 则表达式  $y += z-- / ++x$  的值是 ( )

(Assume  $x = 1$ ,  $y = 2$ ,  $z = 3$ , the value of the expression  $y += z-- / ++x$  is ( ))

- a) 3
- b) 3.5
- c) 4
- d) 4.5

36) Given the following Java code snippet:

```
int x = 1;
int y = 2;
int z = 3;
```

```
y += z-- / ++ x;
```

What is the value of variable y?

- a) 3
- b) 3.5
- c) 4
- d) 4.5

(2037) Adapted from Q56, page 21 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]  
Original: the same with 2036

37) Given the following Java code snippet:

```
int x = 1;  
int y = 1;  
int z = 1;  
y += z-- / ++ x;
```

What are the values of variables z and x, respectively?

- a) 1, 1
- b) 0, 2
- c) 2, 0
- d) 2, 1

(2038) Adapted from Q1, page 22 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: 已知: int a = 8, b = 6; 则, 表达式++a-b++的值是 ()

(Given that int a = 8, b = 6, the value of the expression ++a-b++ is ())

38) Given the following Java code snippet:

```
int a = 8;  
int b = 6;  
int c = ++a - b++;
```

What is the value of c?

- a) 2
- b) 1
- c) 3
- d) 4

(2039) Adapted from Q1, page 22 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]  
Original: the same with 2038

39) Given the following Java code snippet:

```
int a = 3;  
int b = 4;  
int c = ++a - ++b;
```

What is the value of c?

- a) -2
- b) -1
- c) 3
- d) 4

(2040) Adapted from Q1, page 22 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: the same with 2038

40) Given the following Java code snippet:

```
int a = 7;
int b = 6;
float c = a / b;
```

What is the value of c?

- a) 1.1666666...
- b) 1.0
- c) 1
- d) 0

(2041) Adapted from Q1, page 22 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: the same with 2038

41) Given the following Java code snippet:

```
int a = 2;
int b = 3;
double c = a + b;
```

What is the value of c?

- a) 5
- b) 5.0
- c) 5.00
- d) 2 + 3

(2042) Self-developed

42) Which of the following is the "and" operator in Java?

- a) ||
- b) and
- c) &&
- d) \*

(2043) Self-developed

43) Which of the following is the "or" operator in Java?

- a) ||
- b) or
- c) &&
- d) !=

(2044) Adapted from Q22, page 22 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: int x = 2, y = 5; boolean b; b = ++x > 4 && ++y < 3;,, 则x, y, b的值为 ()

(int x = 2, y = 5; boolean b; b = ++x > 4 && ++y < 3;,, the values of x, y, b are ())

44) Given the following Java code snippet:

```
int x = 2;
int y = 5;
boolean b = ++x > 4 && ++y < 3;
```



What are the values of x and y, respectively?

- a) 2, 5
- b) 3, 5
- c) 2, 6
- d) 3, 6

(2045) Adapted from Q22, page 22 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: the same with 2044

45) Given the following Java code snippet:

```
int x = 2;
int y = 5;
boolean b = ++x > 4 && ++y < 3;
```

What is the value of b?

- a) 0
- b) 1
- c) true
- d) false

(2046) Adapted from Q23, page 22 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: float f = 33.7; f = f % 10;; 则 f 的值为 \_\_\_\_  
(float f = 33.7; f = f % 10;; the value of f is \_\_\_\_)

46) Given the following Java code snippet:

```
float a = 33;
a = a % 10;
```

What is the value of a?

- a) 3
- b) 33
- c) 10
- d) Error

(2047) Adapted from Q4, page 23 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: the same with problem 2020

47) Given the following Java code snippet:

```
int c = 1;
System.out.print(c);
System.out.print(c++);
System.out.print(c);
```

What is the output?

- a) 111
- b) 121
- c) 122
- d) 112

(2048) Adapted from Q4, page 23 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: the same with problem 2020

48) Given the following Java code snippet:

```
int c = 1;
System.out.print(c);
System.out.print(++c);
System.out.print(c++);
```

What is the output?

- a) 111
- b) 122
- c) 123
- d) 112

(2049) Adapted from Q3, page 1 in "《JAVA Programming》Final Exam Questions and Answers", 2019, Baidu Library [2]

Original: 设  $x = 2$ , 则表达式  $(x++) / 3$  的值是 \_\_\_\_  
(Assume  $x = 2$ , the value of the expression  $(x++) / 3$  is \_\_\_\_)

49) Given the following Java code snippet:

```
int x = 2;
System.out.println(x++ / 3);
```

What is the output?

- a) 0
- b) 1
- c) 2
- d) 3

(2050) Adapted from Q3, page 1 in "《JAVA Programming》Final Exam Questions and Answers", 2019, Baidu Library [2]

Original: the same with 2049

50) Given the following Java code snippet:

```
int x = 2;
System.out.println(++x / 3);
```

What is the output?

- a) 0
- b) 1
- c) 2
- d) 3

(2051) Self-developed

51) Which of the following is the correct parameter for the main method?

- a) String args
- b) String[] args
- c) Char args
- d) StringBuffer args[]

(2052) Adapted from Q11, page 6 in "《JAVA Programming》Final Exam Questions and Answers", 2019, Baidu Library [2]

Original: 以下代码段执行的输出结果为 ( )  
(the output of the following code is ( ))

```
int x = -3;
int y = -10;
System.out.println(x % y);
```

- a) -1
- b) 2
- c) 1
- d) 3

52) Given the following Java code snippet:

```
int x = -3;
int y = -10;
System.out.println(x % y);
```

What is the output?

- a) 2
- b) 1
- c) -3
- d) 3

(2053) Adapted from Q38, page 20 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: 若定义有变量float f1, f2 = 8.0; 下列说法正确的是 ( )

(Assume we have float f1, f2 = 8.0; which of the following is TRUE())

- a) 变量f1, f2均被初始化为8.0  
(The variables x and y are both declared and initialized to 8.0)
- b) 变量f1没有被初始化, f2被初始化为8.0  
(Only variable f2 is initialized to 8.0, while f1 is not)
- c) 变量f1, f2均未被初始化  
(None of the variables are initialized)
- d) 变量f2没有被初始化, f1被初始化为8.0  
(Only variable f1 is initialized to 8.0, while f2 is not)

53) Which of the following is TRUE about the statement "double x, y = 1.0;"?

- a) The variables x and y are declared and initialized to 1.0 at the same time
- b) Only variable x is initialized
- c) Only variable y is initialized
- d) None of the variables are initialized

(2054) Adapted from Q38, page 20 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: the same with 2053

54) What is the correct method to declare and initialize x and y at the same time?

- a) boolean x, y = true;
- b) int x = 10, y = 5;
- c) double x, y = 1.0, 1.0;
- d) String x = "abc", String y = "def";

(2055) Self-developed

55) Which of the following is the keyword in Java

- a) name
- b) true
- c) bad
- d) world

(2056) Self-developed

56) Which of the following is TRUE about float and double in Java?

- a) They are the same thing
- b) float has more precision than double
- c) double has more precision than float
- d) float is a 64-bit single-precision floating-point number

(2057) Adapted from Q9, page 12 in "《JAVA Programming》Final Exam Questions and Answers", 2019, Baidu Library [2]

Original: 假设 x = 13, y = 4, 则表达式 x % y != 0 的值是 ( ) , 数据类型是 ( )

(Assume x = 13, y = 4, the value of the expression x % y != 0 is ( ), data type is ( ))

57) Given the following Java code snippet:

```
int x = 13;
int y = 4;
System.out.println(x % y != 0);
```

What is the output?

- a) 0
- b) 1
- c) false
- d) **true**

(2058) Adapted from Q9, page 12 [2], Original: the same with 2057

58) Given the following Java code snippet:

```
int x = 8;
int y = 4;
System.out.println(x % y == 1);
```

What is the output?

- a) 0
- b) 1
- c) **false**
- d) true

## B.2 String I/O

(3001) Self-developed

1) Strings are objects.

- a) **True**
- b) False

(3002) Self-developed

2) Which is the correct way to declare a variable of type String in Java?

- a) variable\_name = String;
- b) **String variable\_name;**
- c) String == variable\_name;
- d) string variable\_name;

(3003) Self-developed

3) Pick the correct method to assign a value to a variable of type String:

- a) a = 45;
- b) a == "45";
- c) **a = "45";**
- d) a 45;

(3004) Self-developed

4) You can call methods on strings.

- a) **True**
- b) False

(3005) Self-developed

5) What is the return type for the String function length()?

- a) **int**
- b) char
- c) double
- d) boolean

(3006) Self-developed

- 6) Index starts from what value for the variable of type String?
- a) 1
  - b) 0
  - c) Depends on the length of the variable
  - d) 2

(3007) Self-developed

- 7) Which is the correct method to concatenate strings?
- a) String 1 ++ String 2;
  - b) String 1 + String 2;
  - c) String 1 = String 2;
  - d) String 1 String 2;

(3008) Self-developed

- 8) The length() of the String "Hello World" is:
- a) 10
  - b) 12
  - c) 9
  - d) 11

(3009) Self-developed

- 9) Strings are immutable.
- a) True
  - b) False

(3010) Self-developed

- 10) The String is a primitive data type.
- a) True
  - b) False

(3011) Self-developed

- 11) The substring( ) method creates a new char array that represents the new string.
- a) True
  - b) False

(3012) Self-developed

- 12) Which is the recommended method to compare two strings?
- a) a == b;
  - b) a.equals(b);

(3013) Adapted from Q1, page 5 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: 阅读下面的程序代码，回答问题

(Answer questions from the following code snippet)

```
String s1 = new String("abcde");
String s2 = new String("abcde");
boolean b1 = s1.equals(s2);
boolean b2 = s1 == s2;
System.out.print(s1 + " " + s2);
```

- 13) What is the output of the following main program?

```
public static void main(String[] args){
    String str1 = "CNIT";
    String str2 = "25501";
    String value = str1+ " " + str2;
    System.out.println(value);
}
```

- a) "CNIT" + "25501"
- b) CNIT 25501
- c) CNIT25501
- d) No output

(3014) Self-developed

14) What is the output of the following main program?

```
public static void main(String[] args){  
    String test = "CNIT";  
    int number = 25501;  
    String value = test + number;  
    System.out.println(value);  
}
```

- a) CNIT + 25501
- b) CNIT 25501
- c) CNIT25501
- d) No output

(3015) Self-developed

15) What is the output of the following main program?

```
public static void main(String[] args) {  
    String test = "abcdef";  
    System.out.println(test.substring(5));  
}
```

- a) ef
- b) a
- c) f
- d) fa

(3016) Self-developed

16) Which of the following is NOT a method of the String class?

- a) equals()
- b) concat()
- c) append()
- d) indexOf()

(3017) Self-developed

17) What type of error will occur in the following code?

```
String s = null;  
s.concat('abc');
```

- a) ArithmeticException
- b) NullPointerException
- c) IOException
- d) ClassNotFoundException

(3018) Self-developed

18) Which value of the following statement is NOT equal to TRUE?

- a) "CNIT 25501" == "CNIT 25501"
- b) "CNIT 25501".equals("CNIT 25501")
- c) "CNIT 25501" = "CNIT 25501"
- d) "CNIT 25501".equals(new String("CNIT 25501"))

(3019) Self-developed

19) Which of the statements returns true?

- a) "CNIT 25501" == "CNIT 25501"
- b) "CNIT".equals("25501")
- c) "CNIT 25501".equals(new String("25501"))
- d) ("CNIT 25501".substring(1, 4)).equals("CNIT")

(3020) Self-developed

20) Which of the following is TRUE for the variable s?

```
String[] s = new String[10];
```

- a) s.length() is 10
- b) s[10] is null
- c) s[9] is null
- d) s[9] is 0

(3021) Adapted from Q3, page 1 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: 应用程序的main方法有以下语句，则输出结果是（）

(Assume we have the following code in the main method. The output is ())

```
String s = "xxxxxxxxxxxx#123#456zzzzz";
int n = s.indexOf("#");
int k = s.indexOf("#", n + 1);
String s2 = s.substring(n + 1, k);
System.out.println(s2);
```

- a) 123456
- b) 123
- c) xxxxxxxxxxxx
- d) zzzzz

21) Assume that we have the following code snippet in the main method:

```
String s = "xxx#123#456";
int n = s.indexOf("#");

String s2 = s.substring(n + 1, 7);
System.out.println(s2);
```

What is the output?

- a) 123
- b) xxxx
- c) 123#
- d) #123

(3022) Adapted from Q3, page 1 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: the same with problem 3021

22) Assume that we have the following code snippet in the main method:

```
String s = "xxx#123#456";
String s2 = s.substring(8, 11);
System.out.println(s2);
```

What is the output?

- a) 456
- b) 123
- c) #45
- d) 3#4

(3023) Adapted from Q1, page 5 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: the same with problem 3013

23) What is the value of the following boolean variable b?

```
String s1 = new String("abc");
String s2 = new String("abc");
boolean b = (s1 == s2);
```

- a) True
- b) False

24) What is the value of the following boolean variable b?

```
String s1 = new String("abc");
String s2 = new String("abc");
boolean b = (s1.equals(s2));
```

- a) true
- b) false

(3025) Adapted from Q1, page 5 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: the same with problem 3013

25) What is the value of the following boolean variable b?

```
String s1 = new String("abc");
String s2 = new String("abc");
boolean b = (s1.equals(new String("abc")));
```

- a) true
- b) false

(3026) Adapted from Q3, page 11 in "《JAVA Programming》Final Exam Questions and Answers", 2019, Baidu Library [2]

Original: 已知如下定义: String s = "story"; 下面哪个语句不是合法的 ()

(Assume we have String s = "story"; which of the following is NOT valid ())

- a) s += "books";
- b) s = s + 100;
- c) int len = s.length;
- d) String t = s + "abc";

26) Assume we have String s = "CNIT"; which of the following is NOT valid (error)?

- a) s += "25501";
- b) s += 10;
- c) int len = s.length;
- d) String temp = s + "a";

(3027) Self-developed

27) Which of the following is FALSE about strings in Java?

- a) s.length() returns the length of the string s
- b) String variables cannot be operated with int variables
- c) A string is an object
- d) A string can be changed after initializing

(3028) Adapted from Q1, page 21 in "《JAVA Programming》Final Exam Questions and Answers", 2019, Baidu Library [2]

Original: 下面程序段执行后的结果是 ()

(The output of the following code is ())

```
String s = new String("abcdefg");

for(int i = 0; i < s.length(); i += 2){
    System.out.print(s.charAt(i));
}
```

- a) aceg
- b) aCEG



- c) abcdefg
- d) abcd

28) Given the following Java code snippet:

```
String s = new String("abcdefg");

for(int i = 0; i < s.length(); i++){
    System.out.print(s.charAt(i));
}
```

What is the output?

- a) abcdefg
- b) bcdefg
- c) gfedcba
- d) Error

(3029) Adapted from Q1, page 21 in "《JAVA Programming》 Final Exam Questions and Answers", 2019, Baidu Library [2]

Original: the same with problem 3028

29) Given the following Java code snippet:

```
String s = new String("abcdefg");

for(int i = s.length() - 1; i >= 0; i-=2){
    System.out.print(s[i]);
}
```

What is the output?

- a) abcd
- b) geca
- c) aceg
- d) fdba

(3030) Adapted from Q1, page 21 in "《JAVA Programming》 Final Exam Questions and Answers", 2019, Baidu Library [2]

Original: the same with problem 3028

30) Assume we have a string variable, String s = "abcd";

Which of the following is the correct method to return the char 'c'?

- a) s[3]
- b) s[2]
- c) s.charAt(2)
- d) s.charAt(3)

(3031) Adapted from Q1, page 21 in "《JAVA Programming》 Final Exam Questions and Answers", 2019, Baidu Library [2]

Original: the same with problem 3028

31) Which of String class methods is used to obtain character at specified index?

- a) char()
- b) Charat()
- c) charat()
- d) charAt()

(3032) Self-develop

32) Which of the following statements are FALSE?

- a) String is a class
- b) Strings in java are mutable
- c) Every string is an object of class String
- d) Java defines a peer class of String, called StringBuffer, which allows a string to be altered

(3033) Self-develop

33) Consider the snippet below. What is the output?

```
String s = "Hello World";  
System.out.println(s.charAt(s.toUpperCase().length()));
```

- a) d
- b) Runtime Exception
- c) D
- d) H

(3034) Adapted from Q1, page 5 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: the same with problem 3013

34) What will be the output of the below snippet of code?

```
String s1 = "Cat";  
String s2 = "Cat";  
String s3 = new String("Cat");  
System.out.print(s1 == s2);  
System.out.print(s1 == s3);
```

- a) truefalse
- b) truetrue
- c) falsefalse
- d) falsetrue

(3035) Self-developed

35) A new object is created when a String variable is initialized.

- a) True
- b) False

(3036) Self-developed

36) Consider the following code,

```
string s=new String();
```

This will create an instance of String with

- a) at least one character
- b) a default character
- c) no characters in it
- d) number of characters in it

(3037) Self-developed

37) What will be the output of the following code?

```
String a=new String();  
System.Out.Println ("a= " +a);
```

- a) null
- b) error
- c) =a
- d) a=

(3038) Self-developed

38) Given the following code segment, what is in the string referenced by s1?

```
String s1 = "xy";  
String s2 = s1;  
s1 = s1 + s2 + "z";
```

- a) xyxyz
- b) xyz
- c) zxy
- d) z

(3039) Self-developed

39) What is the value of pos after the following code executes?

```
String s1 = "acded cad";  
int pos = s1.indexOf("d");
```

- a) 2
- b) 4
- c) 5
- d) 8

(3040) Self-developed

40) Which of these classes is the superclass of String and StringBuffer class?

- a) java.util
- b) java.lang
- c) ArrayList
- d) None of the above

(3041) Self-developed

41) Which of these operators can be used to concatenate two or more String objects?

- a) +
- b) +=
- c) &
- d) ||

(3042) Self-developed

42) Which of these constructors is used to create an empty String object?

- a) String( )
- b) String(void)
- c) String(0)
- d) None of the above

(3043) Self-developed

43) What will be the output of the following Java program?

```
class String_demo  
{  
    public static void main(String args[ ])   
    {  
        char chars[ ] = {'a','b', 'c'};  
        String s = new String(chars);  
        System.out.println(s);  
    }  
}
```

- a) a
- b) b
- c) c
- d) abc

(3044) Self-developed

44) In the following Java code, which code fragment should be inserted at line 3 so that the output will be: "123abc 123abc"?

```
StringBuilder sb1 = new StringBuilder("123");  
String s1 = "123";  
// insert code here  
System.out.println(sb1 + " " + s1);
```

- a) sb1.append("abc"); s1.append("abc");
- b) sb1.append("abc"); s1.concat("abc");
- c) sb1.concat("abc"); s1.append("abc");
- d) sb1.append("abc"); s1 = s1.concat("abc");

## B.3 Control flow

(4001) Self-developed

1) Which of the following is NOT the keyword in Java control flow?

- a) if
- b) elif
- c) while
- d) continue

(4002) Self-developed

2) Which of the following expressions can not be a loop condition in Java?

- a) `i > 0`
- b) `i++`
- c) `i == 1`
- d) `bEqual = str.equals('q')`

(4003) Self-developed

3) What is the output of the following Java code snippet?

```
int i = 10;
while(i > 0){
    i++;
    if(i == 10){
        break;
    }
}
```

- a) The loop will run for 10 times
- b) Infinite loop
- c) The loop will run for once
- d) The loop will not run

(4004) Self-developed

4) What is the output of the following Java code snippet?

```
for( int i = 0; ; ){
    System.out.println(i++);
    break;
}
```

- a) Infinite loop
- b) Syntax error
- c) 0
- d) None

(4005) Self-developed

5) What is the output of the following Java code snippet?

```
int i = 0;

do{
    if (i % 2 == 0){
        i = i + 2;
    }
}while(i < 7);

System.out.println(i);
```

- a) 4
- b) 6
- c) 8
- d) 10

(4006) Self-developed

6) Which of the following is **TRUE** about "for loops" in Java?

- a) **We can have more than one statements in the loop body**
- b) For loops only work for the situation that the number of loops has been determined
- c) For loops cannot be implemented by while loops
- d) The for loops execute the statements in the loop body first, and then execute the condition

(4007) Self-developed

7) Given the following Java code snippet:

```
String s1 = "hello";

if (s1 == "hello"){

    System.out.println("s1 == hello")
}
else{

    System.out.println("s1 != hello")
}
```

What is the output of the above code snippet?

- a) **s1 == hello**
- b) s1 != hello
- c) Error
- d) Nothing happens

(4008) Translated from Q1, page 7 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: 关于选择结构下列哪个说法是正确的? ( )

(Which of the following statements is TRUE?())

- a) if语句和else语句必须成对出现  
(if statement must appear in pairs with the else statement)
- b) if语句可以没有else语句对应  
(if statement can appear without the else statement)
- c) switch结构中每个case语句中必须用break语句  
(Each case statement in a switch structure must have break statements)
- d) switch结构中必须有default语句  
(A switch structure must have default statements)

8) Which of the following statements is TRUE?

- a) The if statement must appear in pairs with the else statement
- b) **The if statement can appear without the else statement**
- c) Each case statement in a switch structure must have break statements
- d) A switch structure must have default statements

(4009) Translated from Q2, page 8 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: while循环和do...while循环的区别是:

(What is the difference between while loops and do...while loops:)

- a) 没有区别, 这两个结构任何情况下效果一样  
(No difference, the two loops are the same thing under all the situation)
- b) while循环比do...while循环效率更高  
(while loops are more efficient than do...while loops)
- c) while循环是先执行后判断, 所以循环体至少执行一次  
(while loops execute the loop first and then check the loop condition, so the loop body at least execute once)
- d) do...while循环是先执行后判断, 所以循环体至少执行一次  
(do...while loops execute the loop first and then check the loop condition, so the loop body at least execute once)

9) What is the difference between while loops and do...while loops?

- a) Same thing
- b) while loops are more efficient than do...while loops
- c) while loops execute the loop first and then check the loop condition
- d) **do...while loops execute the loop first and then check the loop condition**

(4010) Translated from Q3, page 8 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: 关于for循环和while循环的说法哪个正确? ( )

(Which of the following is TRUE about for loops and while loops? ( ))

- a) While循环先判断后执行, for循环先执行后判断  
(while loops execute before checking the loop conditions, but for loops do not)
- b) While循环判断条件一般是程序结果, for循环判断条件一般是非程序结果  
(for loops execute before checking the loop conditions, but while loops do not)
- c) 两种循环任何时候都不能被替换  
(The two loops cannot be replaced by each other)
- d) 两种循环都必须有循环体, 循环体不能为空  
(The two loops must have a loop body, and the loop body cannot be empty)

10) Which of the following is TRUE about for loops and while loops?

- a) while loops execute before checking the loop conditions, but for loops do not
- b) for loops execute before checking the loop conditions, but while loops do not
- c) for loops can be replaced with or adapted to while loops
- d) The two loops must have a loop body

(4011) Translated from Q6, page 15 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: switch语句不能用于下列 \_\_\_\_ 数据类型

(The data type \_\_\_\_ below cannot be used as a condition of a switch structure)

- a) byte
- b) short
- c) char
- d) float

11) Which of the following data types cannot be used as a condition of a switch structure?

- a) byte
- b) float
- c) short
- d) char

(4012) Adapted from Q9, page 16 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: 下面是findSum(int m, int n)方法的定义, 方法调用findSum(1, 4)的返回结果是\_\_\_\_

(findSum(int m, int n) is defined below. What is the value of findSum(1, 4) \_\_\_\_)

```
int findSum(int m, int n){
    int sum = 0;
    for(int i = m; i <= n; i++){
        sum += i;
    }
    return sum;
}
```

- a) 1
- b) 4
- c) 5
- d) 10

12) Given the following Java code snippet:

```
public static int func(int n, int m){

    int sum = 0;
    for(int i = n; i <= m; i++){
        sum += i;
    }

    return sum;
}
```

What is the value of func(1, 3)?

- a) 2
- b) 4
- c) 6
- d) 8

(4013) Adapted from Q9, page 16 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]  
Original: the same with problem 4012

13) Given the following Java code snippet:

```
public static void func(int n, int m){  
  
    for(int i = n; i <=m; i++){  
        if(i % 2 == 0){  
            System.out.println(i);  
        }  
    }  
  
}
```

What is the second output of func(1, 6)?

- a) 2
- b) 4
- c) 6
- d) 8

(4014) Adapted from Q9, page 16 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]  
Original: the same with problem 4012

14) Given the following Java code snippet:

```
public static void func(int n, int m){  
  
    for(int i = n; i <=m; i += 2){  
        System.out.println(i);  
    }  
  
}
```

How many numbers does func(1, 6) output?

- a) 2
- b) 3
- c) 4
- d) Error

(4015) Adapted from Q9, page 16 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]  
Original: the same with problem 4012

15) Given the following Java code snippet:

```
public static int func(int n, int m){  
  
    for(int i = n; i <=m; i++){  
        System.out.println(i);  
    }  
  
}
```

How many numbers does func(1, 6) output (watch out the method type :)?

- a) 2
- b) 3

- c) 4
- d) Error

(4016) Translated from Q21, page 17 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: 下列语句序列执行后, k的值是 ()

(Given the following Java code snippet, the value of k is ())

```
int j = 8;
int k = 15;
for(int i = 2; i != j; i += 6){
    k++;
}
a) 15
b) 16
c) 17
d) 18
```

16) Given the following Java code snippet:

```
int j = 8;
int k = 15;

for(int i = 2; i != j; i += 6){
    k++;
}

What is the value of k?
a) 15
b) 16
c) 17
d) 18
```

(4017) Adapted from Q21, page 17 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: the same with problem 4016

17) Given the following Java code snippet:

```
int j = 8;
int k = 8;

for(int i = 2; i == j; i += 6){
    k++;
}

What is the value of k?
a) 8
b) 9
c) 10
d) 11
```

(4018) Adapted from Q21, page 17 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: 下列语句执行后, j的值是 ()

(Given the following Java code snippet, the value of j is ())

```
int j = 3;
int i = 2;

while(--i != i / j){
    j += 2;
}

a) 2
b) 4
c) 5
d) 6
```



18) Given the following Java code snippet:

```
int j = 3;
int i = 2;

while(--i != i / j){
    j += 2;
}
```

What is the value of j?

- a) 2
- b) 4
- c) 5
- d) 6

(4019) Adapted from Q21, page 17 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: the same with problem 4018

19) Given the following Java code snippet:

```
int i = 2;
int j = 0;

while(++i == i - j){
    j += 2;
}
```

What is the value of j?

- a) 2
- b) 4
- c) 5
- d) 6

(4020) Translated from Q23, page 17 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: 下列语句执行后, i的值是 ( )

(Given the following Java code snippet, the value of i is ( ))

```
int i = 0;

do{
    i += 3;
}while(i < 10);
```

- a) 3
- b) 6
- c) 12
- d) 9

20) Given the following Java code snippet:

```
int i = 0;

do{
    i += 3;
}while(i < 10);
```

What is the value of i?

- a) 3

- b) 6
- c) 12
- d) 9

(4021) Adapted from Q23, page 17 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: the same with problem 4020

21) Given the following Java code snippet:

```
int i = 0;

do{
    i += 2;
}while(i % 6 == 0);
```

What is the value of i?

- a) 3
- b) 6
- c) 12
- d) 9

(4022) Translated from Q24, page 18 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: 下列语句执行后, k的值是 ()

(Given the following Java code snippet, the value of k is ())

```
int i = 6;
int j = 8;
int k = 10;

int n = 5;
int m = 7;

if(!(i < j)){
    k = m + n;
}
else{
    k = m - n;
}
```

- a) 12
- b) 2
- c) -2
- d) 10

22) Given the following Java code snippet:

```
int i = 6;
int j = 8;
int k = 10;
int n = 5;
int m = 7;

if(!(i < j)){
    k = m + n;
}
else{
    k = m - n;
}
```

What is the value of k?

- a) 12
- b) 2
- c) -2
- d) 10

(4023) Adapted from Q24, page 18 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]  
Original: the same with problem 4022

23) Given the following Java code snippet:

```
int i = 1;
int j = 2;
int k = 3;
int n = 4;
int m = 5;

if(!(i < j)){
    k = m * n;
}
else{
    k = m / n;
}
```

What is the value of k?

- a) 20
- b) 3
- c) 1
- d) 10

(4024) Translated from Q25, page 17 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: 下列语句执行后, k的值是 ()

(Given the following Java code snippet, the value of k is())

```
int x = 3;
int y = 5;
int k = 0;

switch(x % y + 3){
    case 0:
        k = x * y;
        break;
    case 6:
        k = x / y;
        break;
    case 12:
        k = x - y;
        break;
    default:
        k = x * y - x;
        break;
}
```

What is the value of k?

- a) 12
- b) 0
- c) 15
- d) -2

(4025) Adapted from Q25, page 17 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: the same with problem 4024

25) Given the following Java code snippet:

```
int x = 3;
int y = 5;
int k = 2;

switch(x * y - 3){
    case 0:
```

```

        k += x * y;
        break;
    case 6:
        k += x / y;
        break;
    case 12:
        k += y - x;
        break;
    default:
        k = x * y - x;
        break;
}

```

What is the value of k?

- a) 17
- b) 4
- c) 0
- d) 12

(4026) Adapted from Q26, page 18 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: 执行完下面的程序段后，输出的结果是 ( )

(Given the following Java code snippet, the output is ( ))

```

char c = '\0';

for(c = 'a'; c < 'z'; c += 3){
    if(c >= 'd'){
        break;
    }
}

System.out.println("\n" + c + "\n");

```

What is the output of the above code snippet?

- a) 'e'
- b) 'f'
- c) 'd'
- d) 'a'

26) Given the following Java code snippet:

```

char c = '\0';

```

```

for(c = 'a'; c < 'z'; c += 3){
    if(c >= 'd'){
        break;
    }
}

```

System.out.println(c);

What is the output of the above code snippet?

- a) e
- b) f
- c) d
- d) a

(4027) Adapted from Q26, page 18 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: the same with problem 4026

27) Given the following Java code snippet:

```

char c = '\0';

for(c = 'a'; c < 'z'; c += 1){
    if(c >= 'd'){
        c += 2;
        break;
    }
}

```

System.out.println(c);

What is the output of the above code snippet?

- a) e
- b) f
- c) d
- d) a

(4028) Adapted from Q27, page 18 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: 执行完下面的程序段后，k的值是（）

(Given the following Java code snippet, the value of k is())

```

int k = 0;

label: for(int i = 1; i < 10; i++){
    for(int j = 1; j < 5; j++){
        k += i + j;
        if(j == 3){
            break label;
        }
    }
}

```

- a) 3
- b) 9
- c) 12
- d) 6

28) Given the following Java code snippet:

```

int k = 0;

for(int i = 1; i < 3; i++){
    for(int j = 1; j < 3; j++){
        k += i + j;
    }
}

```

```
System.out.println(k);
```

What is the output of the above code snippet?

- a) 3
- b) 5
- c) 7
- d) 12

(4029) Adapted from Q27, page 18 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]  
Original: the same with 4028

29) Given the following Java code snippet:

```
int k = 0;

for(int i = 1; i < 3; i++){
    for(int j = 1; j < 3; j++){
        if(i == 2){
            continue;
        }
        k += i + j;
    }
}
```

```
System.out.println(k);
```

What is the output of the above code snippet?

- a) 3
- b) 5
- c) 7
- d) 12

(4030) Adapted from Q27, page 18 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]  
Original: the same with 4028

30) Given the following Java code snippet:

```
int k = 0;

for(int i = 1; i < 3; i++){
    for(int j = 1; j < 3; j++){
        if(i == 1){
            break;
        }
        k += i + j;
    }
}
```

```
System.out.println(k);
```

What is the output of the above code snippet?

- a) 3
- b) 5
- c) 7
- d) 12

(4031) Adapted from Q20, page 42 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]  
Original: 下列循环语句的循环次数是 ( )

(The number of the loop executing in the following code is ( ))

```
int i = 5;

do{
```

```
        System.out.println(i--);
        i--;
    }while(i != 0);
```

a) 5  
b) 无限 (infinite)  
c) 0  
d) 1

31) Given the following Java code snippet:

```
int i = 5;

do{
    i--;
}while(i != 0);
```

How many times will the loop execute?

- a) 3  
b) 4  
c) 5  
d) Infinite loop

(4032) Adapted from Q20, page 42 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: the same with 4031

32) Given the following Java code snippet:

```
int i = 5;

do{
    i--;
}while(i != 0);
```

How many times will the loop execute?

- a) 3  
b) 4  
c) 5  
d) Infinite loop

(4032) Adapted from Q20, page 42 in "JAVA programming final exam questions", 2017,  
Baidu Library [1]

Original: the same with 4031

32) Given the following Java code snippet:

```
int i = 5;

do{
    System.out.println(i--);
    i--;
}while(i != 0);
```

How many times will the loop execute?

- a) 3  
b) 4  
c) 5  
d) Infinite loop

(4033) Adapted from Q2, page 22 in "JAVA programming final exam questions", 2017, Baidu  
Library [1]

Original: 写出以下程序的输出结果\_\_\_\_

(write down the output of the following program)

```
int j = 2;
switch(j){
    case 2:
        System.out.println("Value is two.");
    case 2+1:
        System.out.println("Value is three.");
        Break;
    default:
        System.out.println("Value is " + j);
        Break;
}
```

33) Given the following Java code snippet:

```
int x = 0;
int y = 4;

if(x > 0){
    if(y > 3){
        System.out.println("One");
    }
    else{
        System.out.println("Two");
    }
}
else{
    System.out.println("Three");
}
```

What is the output of the code?

- a) One
- b) Two
- c) Three
- d) Error

(4034) Adapted from Q2, page 22 in "JAVA programming final exam questions", 2017, Baidu  
Library [1]

Original: the same with 4033

34) Given the following Java code snippet:

```
int x = 1;
int y = 2;

if(x > 0){
    if(y > 3){
        System.out.println("One");
    }
    else{
        System.out.println("Two");
    }
}
else{
    System.out.println("Three");
}
```

What is the output of the code?

- a) One
- b) Two
- c) Three
- d) Error



(4035) Adapted from Q2, page 22 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: the same with 4033

35) Given the following Java code snippet:

```
int j = 2;
switch(j){
    case 2:
        System.out.println("The value is two");
    case 2+1:
        System.out.println("The value is three");
        break;
    default:
        System.out.println("The value is " + j);
        break;
}
```

What is the output?

a) The value is two  
The value is three

b) The value is three  
The value is 2

c) The value is two  
The value is 2

d) The value is 2

(4036) Adapted from Q2, page 22 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: the same with 4033

36) Given the following Java code snippet:

```
int i = 1;
switch(i){
    case 1:
        System.out.println("The value is one");
        break;
    case 1+1:
        System.out.println("The value is two");
        break;
    default:
        System.out.println("The value is " + i);
        break;
}
```

What is the output?

a) The value is one

b) The value is two

c) The value is 1

d) Error

(4037) Adapted from Q5, page 11 in "《JAVA Programming》Final Exam Questions and Answers", 2019, Baidu Library [2]

Original: 下面的代码执行后, count的值是什么 ( )

(Given the following code, the value of count is ( ))

```
int count = 1;

for(int i = 1; i <= 5; i++){
    count += i;
}

System.out.println(count);
```

a) 5

- b) 1
- c) 15
- d) 16

37) Given the following Java code snippet:

```
int count = 1;
for(int i = 1; i <= 3; i++){
    count += i;
}
System.out.println(count);
```

What is the value of count?

- a) 3
- b) 5
- c) 7
- d) 9

(4038) Adapted from Q5, page 11 in "《JAVA Programming》 Final Exam Questions and Answers", 2019, Baidu Library [2]  
Original: the same with 4037

38) Given the following Java code snippet:

```
int count = 1;
for(int i = 1; i <= 3; i++){
    if(i % 3 == 0){
        count += i;
    }
}
System.out.println(count);
```

What is the value of count?

- a) 1
- b) 4
- c) 6
- d) 8

(4039) Adapted from Q11, page 12 in "《JAVA Programming》 Final Exam Questions and Answers", 2019, Baidu Library [2]

Original: 以下程序段的输出结果是 ( )

(the output of the following code is ( ))

```
int x = 5;
int y = 6;
int z = 4;

boolean b = (x + y > z && x + z > y && y + z > x)
if(b){
    System.out.println("三角形")
}
else{
    System.out.println("不是三角形")
}
```

39) Given the following Java code snippet:

```
int x = 1;
int y = 2;
int z = 3;

boolean b = (x + y > z && x + z > y && y + z > x)
if(b){
    System.out.println("This is a triangle.")
}
```

```

else{
    System.out.println("This cannot be a triangle.")
}

```

What is the output?

- a) This is a triangle.
- b) This cannot be a triangle.
- c) Null
- d) Error

(4040) Adapted from Q12, page 12 in “《JAVA Programming》 Final Exam Questions and Answers”, 2019, Baidu Library [2]

Original: 以下程序段的输出结果是 \_\_\_\_

(The output of the following code is \_\_\_\_)

```

int a[ ] = {2, 3, 4, 5, 6};
for(int i = a.length - 1; i >= 0; i--){
    System.out.print(a[i] + "");
}

```

40) Given the following Java code snippet:

```

int a[ ] = {1, 2, 3};
for(int i = a.length - 1; i >= 0; i--){

    System.out.print(a[ i ]);

}

```

What is the output?

- a) 123
- b) 321
- c) Null
- d) Error

(4041) Adapted from Q12, page 12 in “《JAVA Programming》 Final Exam Questions and Answers”, 2019, Baidu Library [2]

Original: the same with 4040

41) Given the following Java code snippet:

```

int a[ ] = {2, 3, 1};
int i = a.length - 1;
while(i >= 0){
    System.out.print(a[i]);
    i--;
}

```

What is the output?

- a) 231
- b) 321
- c) 132
- d) 213

## B.4 Array

(5001) Self-developed

1) Pick the correct method to declare a variable array of type Integer:

- a) `int[ ] a;`
- b) `a[ ] int;`
- c) `a int[ ];`
- d) `int a;`

(5002) Self-developed

2) What is the index of the first element in an array?

- a) 1
- b) `array.length()`
- c) 0
- d) 2

(5003) Self-developed

3) You can pass a negative number as an array size.

- a) True
- b) False

(5004) Self-developed

4) What is the index of the last element in an array?

- a) `array.length()`
- b) 0
- c) `1 - array.length()`
- d) `array.length() - 1`

(5005) Self-developed

5) How to create a new array of 50 integers?

- a) `int[ ] b = int[50];`
- b) `int[ ] b = new int[50];`
- c) `new int[ ] b = int[50];`
- d) `int[ ] b = b int[50];`

(5006) Self-developed

6) You can use Arrays to store values of either primitive types or reference types.

- a) True
- b) False

(5007) Self-developed

7) Which of the following statements is TRUE about copying array variables:

- a) Creates a new array referenced by the copied variable.
- b) Yields two references to the same array
- c) Cannot copy array variables
- d) Deletes the first array and creates a new array

(5008) Self-developed

8) What is the output of the following code?

```
public static void main(String[ ] args){  
    int[ ] i = new int[0];  
    System.out.println(i[0]);  
}
```

- a) 0
- b) i
- c) `int[ ] i`
- d) `ArrayIndexOutOfBoundsException`

(5009) Self-developed

9) The size of the array can be changed after defining it.

- a) True
- b) False

(5010) Self-developed

10) A new element can be added to an array by simply appending it to the array.

- a) True
- b) False

(5011) Self-developed

11) Which is the correct method to initialize a multidimensional(2d) array of type Integer?

- a) `int [row] [column] a = new int [row] [column];`
- b) `int [column] [row] a = new int [row] [column];`
- c) `int [ ] [ ] a = new int [row] [column];`
- d) `int [ ] [ ] a = new int [column] [row];`

(5012) Self-developed

12) Which of the following are legal methods to declare arrays?

- a) `int [ ] a;`
- b) `int a[ ];`
- c) None of the above
- d) a) and b)

(5013) Self-developed

13) What is the output of the following main method?

```
public static void main(String[ ] args) {  
    int[ ][ ] matrix = {  
        {12, 1, 0},  
        {1, 12, 0},  
        {0, 12, 1}  
    };  
    System.out.println(matrix[1][2]);  
}
```

- a) 12
- b) 0
- c) 1
- d) No output

(5014) Self-developed

14) In this code, args is considered to be a/an,

```
public static void main(String[] args)  
{  
    //some code;  
}
```

- a) Class
- b) Integer
- c) Constant
- d) Array

(5015) Self-developed

15) What is the output of the following main method?

```
public static void main(String[ ] args)  
{
```

```
String[] vowels = {"a", "e", "i", "o", "u"};
System.out.println(vowels[1] + vowels[3]);

}
```

- a) oe
- b) eo**
- c) ai
- d) ia

(5016) Self-developed

16) What is the output of the following code?

```
public static void main(String[] args)
{
    String[] str = {"a","b","c","d","e"};
    System.out.println(str[5]);
}
```

- a) e
- b) a
- c) ea
- d) ArrayIndexOutOfBoundsException**

(5017) Adapted from Q6, page 29 in "《JAVA Programming》 Final Exam Questions and Answers", 2019, Baidu Library [2]

Original: 应用程序的main方法中有以下语句, 则执行后的输出结果为 ( )

(Assume we have the following code snippet in the main method. The output is ( ))

```
int[] x = {125, 21, 5, 168, 98};
int min = x[0];
for(int i = 1; i < x.length; i++){
    if (x[i] < min){
        min = x[i];
    }
}
System.out.println(min);
```

- a) 125
- b) 5**
- c) 98
- d) 168

17) What is the purpose of the following Java code snippet?

```
temp = score[0];
for(int index = 1; index < 5; index++){
    if (score[index] > temp){
        temp = score[index];
    }
}
```

- a) Find the maximum value**
- b) Find the minimum value
- c) Iterate over the array
- d) Error

(5018) Self-developed

18) Which of the following is the correct method for array initializing?

- a) `Int[] a;`

- b) a = {1, 2, 3};
- c) int[] a = new int[5]{1, 2, 3};
- d) int[] a = new int[5];

(5019) Self-developed

19) Which of the following statements is **FALSE** in Java?

- a) Arrays should be declared before using
- b) An array is an object
- c) Array is one of the basic data types in Java
- d) The default value of a boolean array is "false"

(5020) Self-developed

20) An array is an object

- a) True
- b) False

(5021) Adapted from Q10, page 22 in "《JAVA Programming》Final Exam Questions and Answers", 2019, Baidu Library [2]

Original: 应用程序的main方法中有以下语句, 则输出的结果是 ( )

(Assume we have the following code snippet in the main method. What is the output?)

```
int b[][] = {{1, 1, 1}, {2, 2}, {3}};
int sum = 0;

for(int i = 0; i < b.length; i++){
    for (int j = 0; j < b[i].length; j++){
        sum += b[i][j];
    }
}

System.out.println("sum=" + sum);
```

- a) 32
- b) 11
- c) 2
- d) 3

21) Assume that we have the following code in the main method:

```
int b[][] = {{1, 1, 1}, {2, 2}, {3}};
int sum = 0;

for(int i = 0; i < b.length; i++){
    for (int j = 0; j < b[i].length; j++){
        sum += b[i][j];
    }
}

System.out.println(sum);
```

What is the output?

- a) 10
- b) 7
- c) 3
- d) 6

(5022) Adapted from Q10, page 22 in “《JAVA Programming》Final Exam Questions and Answers”, 2019, Baidu Library [2]

Original: the same with problem 5021

22) Assume that we have the following code in the main method:

```
int b[ ][ ] = {{1, 1, 1}, {2, 2}, {3}};
int sum = 0;

for(int i = 0; i < b.length; i++){
    sum += b[i];
}
```

System.out.println(sum);

What is the output?

- a) 10
- b) 7
- c) 3
- d) 6

What is the output?

- a) 10
- b) 7
- c) 3
- d) 6

(5023) Translated from Q6, page 3 in “JAVA programming final exam questions”, 2017, Baidu Library [1]

Original: 应用程序的main方法中有以下语句, 则执行后的输出结果为 ( )

(Assume we have the following code snippet in the main method. The output is ( ))

```
int [ ]x = {125, 21, 5, 168, 98};
int min = x[0];
for(int i = 1; i < x.length; i++){
    if (x[ i ] < min){
        min = x[ i ];
    }
}
System.out.println(min);
```

- a) 125
- b) 5
- c) 98
- d) 168

23) Assume that we have the following code in the main method:

```
int[ ] x = {125, 21, 5, 168, 98};
int temp = x[0];

for(int i = 0; i < x.length; i++){
    if(x[ i ] < temp)
        temp = x[ i ];
}
```

System.out.println(temp);

What is the output?

- a) 21
- b) 168
- c) 5
- d) 98



(5024) Adapted from Q6 page 3 in "JAVA programming final exam questions", 2017, Baidu  
Library [1]

Original: The same with problem 5023

24) Assume that we have the following code in the main method:

```
int[] x = {125, 21, 5, 168, 98};  
int temp = x[0];  
  
for(int i = 0; i < x.length; i++){  
    if(x[i] > temp)  
        temp = x[i];  
}
```

System.out.println(temp);

What is the output?

- a) 21
- b) 168
- c) 5
- d) 98

(5025) Adapted from Q6, page 3 in "JAVA programming final exam questions", 2017, Baidu  
Library [1]

Original: the same with problem 5023

25) Assume that we have the following code in the main method:

```
int[] x = {125, 21, 5, 168, 98};  
int temp = x[0];  
  
for(int i = 0; i < x.length; i++){  
    if(x[i] > temp)  
        temp = x[i];  
}
```

System.out.println(temp);

How many times will the loop execute?

- a) 2
- b) 3
- c) 4
- d) 5

(5026) Adapted from Q4, page 4 in "JAVA programming final exam questions", 2017, Baidu  
Library [1]

Original: 定义如下二维数组b，下面的说法正确的是（）

(Given the 2d array b, which of the following is TRUE())

```
int b[][] = {{1, 2, 3}, {4, 5}, {6, 7, 8}};
```

- a) b.length的值是3 (The value of b.length is 3)
- b) b[1].length的值是3 (The value of b.length[1] is 3)
- c) b[1][1]的值是5 (The value of b[1][1] is 5)
- d) 二维数组b的第一行有3个元素 (The first row of the 2d array b has 3 elements)

26) Given the following array b:

```
int b[][] = {{1, 2, 3}, {4, 5}, {6, 7, 8}};
```

Which of the following is NOT TRUE?

- a) b.length equals to 3
- b) b[1][1] equals to 5
- c) b[1].length equals to 3
- d) The first row of the array b has 3 numbers

(5027) Adapted from Q4, page 4 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: the same with problem 5026

27) Given the following array b:

```
int b[ ][ ] = {{1, 2, 3}, {4, 5}, {6, 7, 8}};
```

Which of the following is true?

- a) b.length equals to 2
- b) b[2][1] equals to 7
- c) b[2].length equals to 2
- d) b[1][1] equals to 1

(5028) Adapted from Q7, page 27 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: 设有数组定义int MyIntArray = {10, 20, 30, 40, 50, 60, 70}; 则执行以下几个语句后的输出结果是\_\_\_\_\_。

(Given the array, int MyIntArray = {10, 20, 30, 40, 50, 60, 70}; what is the output of the following Java code\_\_\_\_\_)

```
int s = 0;
for(int i = 0; i < myArray.length; i++){
    if(myArray[i] % 2 == 1){
        s += MyIntArray[i];
    }
}
System.out.println(s);
```

28) Given the following Java code snippet:

```
int myArray[ ] = {1, 2, 3, 4, 5};
int temp = 0;
for(int i = 0; i < myArray.length; i++){
    if(myArray[ i ] % 2 == 0){
        temp += myArray[ i ];
    }
}
```

What is the value of temp?

- a) 2
- b) 4
- c) 6
- d) 8

(5029) Adapted from Q7, page 27 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: the same with problem 5028

29) Given the following Java code snippet:

```
int myArray[ ] = {2, 4, 6, 8};
int temp = 0;
for(int i = 0; i < myArray.length; i++){
    if(myArray[ i ] % 2 != 0){
        temp += myArray[ i ];
    }
}
```

What is the value of temp?

- a) 0
- b) 2
- c) 4
- d) 6

(Given the following Java code, which of the following statements is correct? ( ))

```
Public class Person{
    Static int arr = new int [5];
    Public static void main(String args[]){
        System.out.println(arr[0]);
    }
}
```

- a) 编译时将产生错误 (Error when compiling)
- b) 编译时正确, 运行 (Compile correctly)
- c) 输出零 (Output 0)
- d) 输出空 (Output None)

30) Given the following Java code snippet:

```
int arr[ ] = new int[5];
system.out.println(arr[0]);
```

What is the output?

- a) 0
- b) 1
- c) null
- d) Error

(5031) Adapted from Q8, page 5 in “《JAVA Programming》Final Exam Questions and Answers”, 2019, Baidu Library [2]  
Original: the same with 5030

31) Given the following Java code snippet:

```
boolean arr[ ] = new boolean[3];
system.out.println(arr[2]);
```

What is the output?

- a) false
- b) true
- c) 0
- d) 1

(5032) Adapted from Q2, page 21 in “《JAVA Programming》Final Exam Questions and Answers”, 2019, Baidu Library [2]

Original: 有整型数组, int[ ] x = {12, 35, 8, 7, 2};, 则调用方法Arrays.sort(x)后, 数组x中的元素值依次是 ( )

(Given an integer array, int [ ]x = {12, 35, 8, 7, 2}), what is the order of the elements in x when we call the method Arrays.sort(x)

- a) 2 7 8 12 35
- b) 12 35 8 7 2
- c) 35 12 8 7 2
- d) 8 7 12 35 2

32) Given the following Java code snippet:

```
int[ ] x = {12, 35, 8, 7, 2};
System.out.println(Arrays.sort(x));
```

What is the output?

- a) [12, 35, 8, 7, 2]

- b) [2, 7, 8, 12, 35]
- c) [35, 12, 8, 7, 2]
- d) [8, 7, 12, 35, 2]

(5033) Adapted from Q6, page 3 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: the same with problem 5023

33) Given the following Java code snippet:

```
int[] x = {125, 21, 5, 168, 98};
int temp = x[0];

for(int i = 0; i < x.length; i++){
    if(x[i] > temp){
        temp = x[i];
    }
}
```

What is the value of temp?

- a) 125
- b) 98
- c) 168
- d) 5

(5034) Self-developed

34) Given the following Java code snippet:

```
int[] x = {81, 90, 6, 72, 14};
int temp = x[0];

int temp = x[0];

for(int i = x.length - 1; i >= 0; i -= 2){
    if(x[i] < temp){
        temp = x[i];
    }
}
```

What is the value of temp?

- a) 81
- b) 6
- c) 90
- d) 14

(5035) Self-developed

35) What is the output of the following main function?

```
public static void main(String[] args)
{
    String[] vowels = {"1", "2", "3", "4", "5"};
    System.out.println(vowels[1] + vowels[5]);
}
```

- a) 15
- b) 25
- c) 14
- d) ArrayIndexOutOfBoundsException

(5036) Adapted from Q6, page 3 in "JAVA programming final exam questions", 2017, Baidu  
Library [1] Original: the same with problem 5023

36) What is the purpose of the following Java code snippet?

```
temp = score[0];  
for(int index = 1; index < 5; index++){  
    if (score[index] < temp){  
        temp = score[index];  
    }  
}
```

- a) Find the maximum value
- b) Find the minimum value
- c) Iterate over the array
- d) Error

(5037) Self-developed

37) Given the following Java code snippet:

```
int[] x = {0, 11, 22, 33, 44};  
System.out.println(x[x.length-2]);
```

What is the output?

- a) 11
- b) 22
- c) 33
- d) 44

(5038) Self-developed

38) Arrays can be multi-dimensional in Java.

- a) True
- b) False

(5039) Self-developed

39) Is the following declaration TRUE?

```
int y = 56;  
int[] number = {12, 34, 90, y, 65};
```

- a) True
- b) False

(5040) Self-developed

40) Arrays can store multiple elements of different data types.

- a) True
- b) False

(5041) Self-developed

41) Using the correct index, we can fetch data elements of an array at run time.

- a) True
- b) False

(5042) Self-developed

42) If the array is of an Object type, the default value of the array elements are:

- a) null
- b) None
- c) False
- d) None of the above

(5043) Self-developed

43) Which of the following declarations will cause a compile time error?

- a) `int[] scores = null;`
- b) `String[] nameArray = {5, 3, 2};`
- c) `int[] scoreArray = {50, 90, 85};`
- d) `String[] nameArray = new String[10];`

(5044) Self-developed

44) What is returned from `arr[3]` if `arr={6, 3, 1, 2}`?

- a) 6
- b) 3
- c) 1
- d) 2

(5045) Self-developed

45) Given the following code snippet, what is the output?

```
private int[] a = {1, 3, -5, -2};

public void loop()
{
    int amt = 5;
    int i = 0;
    while (i < a.length)
    {
        a[i] = a[i] * amt;
    }
    System.out.println(a);
}
```

- a) {5,15,-25,-10}
- b) {5,3,-5,-2}
- c) {-2,-5,3,1}
- d) No output due to infinite loop

(5046) Self-developed

46) What is the output of the following code fragment?

```
int[] odd = {1, 3, 5, 7, 9, 11};
System.out.println( odd[0] + " " + odd[3] );
```

- a) 1 5
- b) 6
- c) 1 7
- d) No output

(5047) Self-developed

47) What is the output of the following code fragment?

```
int[] nums = {2, 4, 6, 8, 10};
nums[0] = 44;
nums[4] = nums[2];
System.out.println(nums[0] + " " + nums[4]);
```

- a) 44 6
- b) 44 10
- c) 2 4
- d) 446

(5048) Self-developed

48) What is the length of this array?

```
double[] stuff = {1.5, 2.5, 3.5, 4.5, 5.5, 6.5};
```

- a) 6
- b) 7
- c) 5
- d) 4

(5049) Self-developed

49) Which code line could possibly "call" this method?

```
public static int SomeMethod(double[] array, int[] number){
    //somecode
}
```

- a) `int value = SomeMethod(money, grades);`
- b) `SomeMethod(money, grades);`
- c) `double value = SomeMethod(money, grades);`
- d) `int value = SomeMethod(money);`

(5050) Self-developed

50) The length of an array in Java CANNOT be zero

- a) True
- b) False

(5051) Self-developed

51) If an index value is less than 0 or greater than or equal to 'arrayname'.length in an array element access expression, an \_\_\_\_ is thrown.

- a) ArrayOutOfBoundsException
- b) ArrayIndexOutOfBoundsException
- c) ArrayIndexOutOfBoundsException
- d) ArrayIndexIsOutOfBoundsException

(5052) Self-developed

52) The ith element in the array has an index \_\_\_\_

- a) i
- b) i - 1
- c) i + 1
- d) None of above

(5053) Self-developed

53) In Java, each array object has a final field named \_\_\_\_ that stores the size of the array.

- a) width
- b) size
- c) length
- d) distance

## B.5 Classes

(6001) Self-developed

1) What is the keyword for creating a method that can be called without creating any object instances?

- a) static
- b) final
- c) hidden
- d) public

(6002) Self-developed

2) An object is an instance of a class.

- a) True
- b) False

(6003) Self-developed

3) Which of the following is a wrapper class in Java?

- a) int
- b) Integer
- c) double
- d) None of the above

(6004) Adapted from Q4, page 35 in "《JAVA Programming》Final Exam Questions and Answers", 2019, Baidu Library [2]

Original: 下列修饰符中与访问控制无关的是 ( )

(Which of the following is NOT an access control modifier ( ))

- a) private
- b) public
- c) protected
- d) final

4) Which of the following is NOT an access modifier for members of a class?

- a) public
- b) private
- c) protected
- d) None of the above

(6005) Self-developed

5) An object has:

- a) Behavior
- b) State
- c) Identity
- d) All of the above

(6006) Self-developed

6) Which of the following keywords is used for creating objects in Java?

- a) create
- b) instanceof
- c) return
- d) New

(6007) Adapted from Q4, page 35 in "《JAVA Programming》 Final Exam Questions and Answers", 2019, Baidu Library [2]

Original: the same with problem 7004

7) Which of the following keywords are used to declare that a field cannot change?

(Base 4)

- a) final
- b) private
- c) static
- d) None of the above

(6008) Self-developed

8) While calling a method, the arguments have to be passed in the same order as defined in the method.

- a) True
- b) False

(6009) Self-developed

9) The keyword is used to declare that only one field is needed per class.

- a) public
- b) private
- c) static
- d) None of the above

(6010) Self-developed

10) Math.pow(a,b) computes a raised to the power b, this happens by:

- a) Calling the static method pow() in the Math class
- b) Creating an object of type Math and then calling the method pow()
- c) No methods are called
- d) None of the above

(6011) Self-developed

11) A method can mutate objects.

- a) True
- b) False

(6012) Self-developed

12) A void method can return a value.

- a) True
- b) False

(6013) Self-developed

13) When you pass a parameter to a method, which of the following is true:

- a) The method can change the value of the variable
- b) Call by value is used where the method gets copies of the argument values
- c) None of the above
- d) a) and b)



(6014) Self-developed

14) In a public class, you can access which of the following:

- a) Class
- b) Method
- c) Field
- d) All of the above

(6015) Self-developed

15) Encapsulation is a concept in Object Oriented Programming for combining properties and methods of an object in a single unit.

- a) True
- b) False

(6016) Self-developed

16) What is the correct way to call a method of a class?

- a) Class\_name.method\_name();
- b) Class\_name method\_name();
- c) method\_name();
- d) Class\_name(method\_name);

(6017) Self-developed

17) An abstract class need not have one or more abstract methods.

- a) True
- b) False

(6018) Self-developed

18) What are the instance variables in the following code:

```
public class IdentifyMyParts {  
    public static int x = 7;  
    public int y = 3;  
}
```

- a) x
- b) y
- c) x and y
- d) None of the above

(6019) Self-developed

19) What are the class variables in the following code:

```
public class IdentifyMyParts {  
    public static int x = 7;  
    public int y = 3;  
}
```

- a) x
- b) y
- c) x and y
- d) None of the above

(6020) Self-developed

20) Which of the following statements is **TRUE** in Java?

- a) An instance method can directly call the instance method of the super class
- b) An instance method can directly call a super class method
- c) An instance method can directly call methods of other classes
- d) An instance method can directly call methods of the current class

(6021) Translated from Q10, page 10 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: 关于方法main()的说法哪一个是正确的? ( )

(Which of the following statements is TRUE about the main() method)

- a) 方法main()只能放在公共类中  
(the main() method can only be placed in a public class)
- b) main()的头定义可以根据情况任意更改  
(the definition of the main() can be changed based on different situations)
- c) 一个类中可以没有main()方法  
(there can be no main() method in a class)
- d) 所有对象的创建都必须在main()方法中  
(objects must be created in the main() method)

21) Which of the following statements is **TRUE** in Java?

- a) A class can have more than one main methods
- b) **The main method must be included in a class**
- c) The name of the main method must be the same as the .java filename
- d) If there is only one statement in the main method, {} can be not used

(6022) Self-developed

22) Which of the following statements is **TRUE** for object-oriented programming?

- a) **Classes simulate entities in the real world**
- b) We should create as many classes as there are entities
- c) Entities in the real world cannot be described by classes
- d) The behavior and attributes of the object are encapsulated in the class and the outside obtains it by calling the method of the class

(6023) Self-developed

23) How many constructor method(s) are there in the following Java class?

```
public class Test{
    private int x;

    public Test(){
        x = 35;
    }

    public void Test(double f){

        this.x = (int)f;

    }

    public Test(String s){}
}
```

- a) 0
- b) 1
- c) **2**
- d) 3

(6024) Adapted from Q11, page 9 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: 构造函数何时被调用? ( )

(When will the constructor method be called?)

- a) 创建对象时 (when creating an object)
- b) 类定义时 (when defining a class)
- c) 使用对象方法时 (when using the methods of an object)
- d) 使用对象属性时 (when using the attributes of an object)

24) Which of the following is **TRUE** about constructor methods in Java?

- a) **Constructor methods will be automatically created by the compiler**
- b) We must manually declare constructor methods in Java
- c) The code still can run without declaring constructor methods, therefore, constructor methods are not necessary for Java classes
- d) We can only have one constructor method in a Java class

(6025) Self-developed

25) Given the following Java code snippet:

```
class Test{

    private int m;

    public static void fun(){

        \\ some code

    }

}
```

What should we do if we want the member variable m to be directly accessed by the function fun()?

- a) Change the statement "private int m" to "protected int m"
- b) Change the statement "private int m" to "public int m"
- c) Change the statement "private int m" to "static int m"
- d) Change the statement "private int m" to "int m"

(6026) Self-developed

26) Given the following Java code snippet:

```
class Test{

    public int m;

    public static void fun(){

        \\ some code

    }

}
```

The member variable m can be directly accessed by the function fun()

- a) True
- b) False

(6027) Self-developed

27) What is the output for the following Java code snippet?

```
public class Test{

    string x = "1";
    int y;

    public static void main(String args[]){

        int z = 2;
        system.out.println("x+y+z");

    }

}
```

- a) 3
- b) 102
- c) 12
- d) Error

(6028) Self-developed

28) What is the output for the following Java code snippet?

```
public class Test{

    public static void main(String args[]){

        String x = "1";
        int y = 2;
        int z = 3;
        system.out.println("x+y+z");

    }

}
```

- a) 123
- b) 3
- c) 5
- d) Error

(6029) Adapted from Q1, page 3 in "JAVA programming final exam questions", 2017, Baidu Library [1]

- Original: 下面哪些关键字能用来控制对类成员的访问? ( )  
(Which of the following keywords can control the access to members of a class?)
- a) public
  - b) protected
  - c) private
  - d) Default

- 29) Which of the following keywords CANNOT control the access to members of a class?
- a) private
  - b) public
  - c) default
  - d) protected

(6030) Adapted from Q1, page 3 in "JAVA programming final exam questions", 2017, Baidu Library [1]

- Original: the same with problem 6029
- 30) Which of the following is NOT an access control modifier?
- a) private
  - b) final
  - c) protected
  - d) public

(6031) Adapted from Q5, page 9 in "JAVA programming final exam questions", 2017, Baidu Library [1]

- Original: void的含义 ( )  
(What is the meaning of void?)
- a) 方法没有返回值 (the method does not return value)
  - b) 方法体为空 (the method body is empty)
  - c) 没有意义 (no meaning)
  - d) 定义方法时必须使用 (must be used when we define methods)
- 31) Which of the following is TRUE about the **void** modifier?
- a) void methods are empty methods, having no statements in the body
  - b) void methods have no meaning
  - c) void methods do not return values
  - d) void methods are used when we define methods

(6032) Translated from Q11, page 9 in "JAVA programming final exam questions", 2017, Baidu Library [1]

- Original: the same with problem 6024
- 32) When will the constructor methods be called?
- a) When we define a class
  - b) When we use the attributes of an object
  - c) When we create an object
  - d) When we use the methods of an object

(6033) Self-developed

- 33) The keyword **this** cannot be used in a static method
- a) True
  - b) False

(6034) Self-developed

- 34) The keyword **this** stands for an object of the current class
- a) True
  - b) False

(6035) Self-developed

35) Which of the following is TRUE about the keyword **this**?

- a) **this** can be used in a static method
- b) **this** can be used in the main method
- c) **this is an object of the current class**
- d) **this** cannot access member variables

(6036) Self-developed

36) What is the type of the main method in Java?

- a) **void**
- b) int
- c) String
- d) float

(6037) Translated from Q34, page 20 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: 下面哪些选项是正确的main()方法说明?

(Which of the following is the correct main() method?)

- a) void main()
- b) **private static void main(String args[ ])**
- c) public main(String args[ ])
- d) public static void main(String args[ ])

37) Which of the following is the correct main method in Java?

- a) void main( )
- b) private static void main(String args[ ])
- c) **public static void main(String args[ ])**
- d) public void main(String args[ ])

(6038) Adapted from Q31, page 18 in "JAVA programming final exam questions", 2017, Baidu Library [1]

Original: 下面关于Java Application程序结构特点描述中, 错误的是 ( )

(Which of the following statements is FALSE about Java Application())

- a) 一个Java Application程序由一个或多个文件组成, 每个文件可以定义一个或多个类, 每个类由若干个方法和变量组成  
(A Java Application is comprised of one or more files, and each file can define one or more classes, and each class is comprised of one or more methods and variables)
- b) Java程序中声明有public类时, 则Java程序文件名必须与public类的类名相同, 并区分大小写, 扩展名为.java  
(In a Java program, the name of .java file must be the same as that of the public class, and it is case-sensitive)
- c) 组成Java Application程序的多个类中, 有且仅有一个主类  
(There can only be one main method in a Java program)
- d) 一个.java文件定义多个类时, 允许其中声明多个public类  
(We can declare more than one public class in a .java file)

38) Which of the following statements is FALSE about Java programs?

- a) There can only be one main method in a Java program
- b) The name of the public class in a Java program must be the same as the name of the .java file
- c) **We can have more than one public class in a Java program**
- d) A Java class is comprised of methods and variables

(6039) Self-developed

39) The correct way to declare a public constant variable "pi" in a Java class is:

- a) public double int pi = 3.14;
- b) **public final double pi = 3.14;**
- c) final public double pi = 3.14;
- d) final double pi = 3.14;

(6040) Adapted from Q1, page 13 in "《JAVA Programming》Final Exam Questions and Answers", 2019, Baidu Library [2]

Original: 以下程序的输出结果为\_\_\_\_

(The output of the following program is \_\_\_\_)

```
public class Person{
    String name;
    int age;

    public University(String name, int age){
        this.name = name;
        this.age = age;
    }

    public static void main(String[] args){
        Person c = new Person("Peter", 17);
        System.out.println(c.name + " is " + c.age + " years old.");
    }
}
```

40) Given the following Java code snippet:

```
public class University{
    String name;
    int age;

    public University(String name, int age){
        this.name = name;
        this.age = age;
    }

    public static void main(String[] args){
        University u = new University("Purdue", 152);
        System.out.println(u.name + " is " + u.age + " years old.");
    }
}
```

What is the output?

- a) is years old.
- b) Purdue 152
- c) Purdue is 152 years old.
- d) Error

(6041) Adapted from Q3, page 14 in "《JAVA Programming》Final Exam Questions and Answers", 2019, Baidu Library [2]

Original: 以下程序的输出结果为\_\_\_\_

(The output of the following program is \_\_\_\_)

```
public class Tom{
    private static String name;
    private float weight;

    public void setweight(float weight){
        this.weight = weight;
    }

    public void out(){
        System.out.println(name + "weight: " + weight);
    }

    public static void main(String[] args){
        Tom.name = "汤姆猫";
        Tom cat = new Tom();
        cat.setweight(20);
        cat.out();
    }
}
```

41) Given the following Java code snippet:

```
public class Cat{
    private static String name;
    private float weight;

    public void setweight(float weight){
        this.weight = weight;
    }

    public void out(){
        System.out.println(name + "weight: " + weight);
    }

    public static void main(String[ ] args){
        Cat.name = "Tom";
        Cat Tom = new Cat();
        Tom.setweight(20);
        Tom.out();
    }
}
```

What is the output?

- a) weight:
- b) weight: 20
- c) Tom weight: 20
- d) Error

(6042) Adapted from Q1, page 17 in "《JAVA Programming》Final Exam Questions and Answers", 2019, Baidu Library [2]

Original: 按要求编写以下程序:

(Implement the following program as required: )

- 1) 创建一个Rectangle类, 添加width和height两个成员变量  
(Create a Rectangle class, adding two members called width and height)
- 2) 在Rectangle类中添加两个方法分别计算周长和面积  
(Create two methods to calculate the perimeter and the area in the Rectangle class)
- 3) 编程利用Rectangle输出一个矩形的周长和面积  
(Output the perimeter and the area of a rectangle)

```
public class Rectangle{
    float width, height;

    public Rectangle(float width, float height){
        this.width = width;
        this.height = height;
    }

    public float getLength(float width, float height){
        return (this.width + this.height) * 2;
    }

    public float getArea(float width, float height){
        return this.width * this.height;
    }

    public static void main(String[] args){
        Rectangle rect = new Rectangle(10, 20);
        System.out.println("周长是: " + rect.getLength());
        System.out.println("面积是: " + rect.getArea());
    }
}
```

42) Given the following Java code snippet:

```
public class Rectangle{
    float width, height;

    public Rectangle(float width, float height){
        this.width = width;
        this.height = height;
    }

    public float getArea(float width, float height){
        return this.width * this.height;
    }

    public static void main(String[] args){
        Rectangle rec = new Rectangle(5, 5);
        System.out.println(rec.getArea());
    }
}
```

What is the output?

- a) 5
- b) 10
- c) 25
- d) Error

(6043) Adapted from Q12, page 23 in “《JAVA Programming》Final Exam Questions and Answers”, 2019, Baidu Library [2]

Original: 程序Test.java编译运行后输出的结果为 ( )  
(What is the output of Test.java())

```
public Test{
    String s1 = "Java";
    public static void main(String[ ] args){
        int z = "1.8";
        Test t = new Test();
        System.out.println(t.s1 + ' ' + z);
    }
}
```

- a) java2
- b) 2
- c) 没有输出结果 (No output)
- d) java

43) Given the following Java code snippet:

```
public Test{
    String s1 = "Java";
    public static void main(String[ ] args){
        int z = "1.8";
        Test t = new Test();
        System.out.println(t.s1 + ' ' + z);
    }
}
```

What is the output?

- a) Java
- b) Java 1.8
- c) 1.8
- d) Error



(6044) Self-developed

- 44) In the Java programming language, the code is placed inside \_\_\_\_.
- a) Classes, Interfaces
  - b) Methods
  - c) Blocks
  - d) All the above

(6045) Self-developed

- 45) A Class in Java is like a \_\_\_\_.
- a) Prototype
  - b) Instruction Sheet
  - c) Blueprint
  - d) All the above

(6046) Self-developed

- 46) In Java, the keyword used to declare a class is \_\_\_\_.
- a) Class
  - b) Java
  - c) class
  - d) java

(6047) Self-developed

- 47) A Java class can contain \_\_\_\_.
- a) Variables
  - b) Methods, Constructors
  - c) Inner Classes (A class inside another class)
  - d) All the above

(6048) Self-developed

- 48) An object is created at \_\_\_\_ time in Java.
- a) Compile-time
  - b) Run time
  - c) Assembling time
  - d) None of the above

(6047) Self-developed

- 47) A Java class can contain \_\_\_\_.
- a) Variables
  - b) Methods, Constructors
  - c) Inner Classes (A class inside another class)
  - d) All the above

(6048) Self-developed

- 48) An object is created at \_\_\_\_ time in Java.
- a) Compile-time
  - b) Run time
  - c) Assembling time
  - d) None of the above

(6049) Self-developed

- 49) Choose the correct statement about the main method in Java.
- a) The main method is not a required method
  - b) The main method must be declared public static void
  - c) You can define program flow using the main method and the Java virtual machine calls the main method directly.
  - d) All the above

(6050) Self-developed

- 50) Creating an object from a class is also called \_\_\_\_.
- a) Initializing
  - b) Instantiating
  - c) Interfacing
  - d) None of the above

(6051) Self-developed

51) The default value of a static integer variable of a class in Java is,

- a) 0
- b) 1
- c) Null
- d) None of the above

(6052) Self-developed

52) Which of the following is a valid declaration of an object of class Box?

- a) `Box obj = new Box();`
- b) `Box obj = new Box;`
- c) `obj = new Box( );`
- d) `new Box obj;`