

Sixth International Conference FMNS-2015  
10 - 14.06.2015, Blagoevgrad, BULGARIA

Mini-conference "Inquiry-Based Approach in Higher Education in  
Mathematics and Informatics"

# **Test system and software for evaluation the students knowledge in programming**

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## *Introduction*

- Best practice, better practice, good practice, no so bad practice, . . .
- A test system for evaluation the students knowledge in programming.
- The test system as a part of the learning process of programming.
- The test system as a Inquiry-Based Approach in Higher Education in Informatics.
- For students: preparing for the test, test, verifying the results.
- For teachers: preparing the test, checking the test, analysing the results.

## *Terminology*

- The test consists of **items**.
- The **stem** is the introductory question or statement at the beginning of each item.
- The stem is followed by the **options**.
- The options are:
  - **answers** – the correct options, and
  - **distractors** – the incorrect options.
- The items are stored in an **item bank**.
- **Individual test** consists of fixed number of items with fixed number of options.

## *Special multiple choice test*

- The individual tests are generated from the test bank randomly.
- The number of options in any individual test is fixed on 4 for all items.
- In any individual test the number of correct options (answers) of an item may be **any number** in the interval  $[0,4]$ ;
- The student have to identify each answer and each distractor. For any option he/she has 3 choices of response:
  - yes, i.e. I know the option is an answer;
  - no, i.e. I know the option is a distractor;
  - nothing, i.e. I do not know whether the option is an answer or a distractor.
- Any correct response (yes or no) **adds** one point in the total score but any incorrect (opposite) response **subtracts** one point (a penalty point) from the total score.

## *Special multiple choice test*

- We estimate an individual test of  $M$  items with  $x$  points total score as follows:

```
int p = ceil(100.0*x/(M*4)), e = 2;  
    if (p >= 90) e = 6;  
else if (p >= 76) e = 5;  
else if (p >= 60) e = 4;  
else if (p >= 50) e = 3;
```

- To calculate the probability of **passing** the test using random method, we choose a test with  $M = 10$  items (maximum 40 points total score).
- Probability is 0.11% in case the student has noted all the options **yes** or **no**.
- Probability is 0.0034% in case the student marked options randomly with **yes**, **no** or **nothing**.

## *Special multiple choice test – procedure*

Before the test time:

- At least one week before the date of the test all original stems and two example options per item (an answer and a distractor) are published online on the course website [w].
- A few days before the test, a general advice is organized on which the issues of the test are discussed.

During the completion of the test [p]:

- The students can use lectures, textbooks and any other printed materials.
- The students are allowed to use computer as a book, or also compiler, or even Internet.
- Anyone can ask a question about ambiguities in the test.

## *Special multiple choice test – procedure*

After the verification of the tests [p]:

- The individual tests are returned to the students.
- Each student should carefully check his/her individual test in order to determine whether he/she agrees with the noted errors.
- If something is not clear she/he can discuss the case.
- It is normal to increase the total score of the student if his/her arguments about the case are reasonable.

## *Inquiry-Based Approach*

According to a definition by Linn, Davis and Bell, **inquiry** is the intentional process of

- diagnosing problems, [understanding the item]
- critiquing experiments, [using compiler]
- distinguishing alternatives, [comparing options]
- planning investigations, [How to search?]
- researching conjectures, [yes, no, nothing]
- searching for information, [in the books and in Internet]
- constructing models, [writing small programs]
- debating with peers, and [+]
- forming coherent arguments. [in discussions after verification]



## *Inquiry-Based Approach*

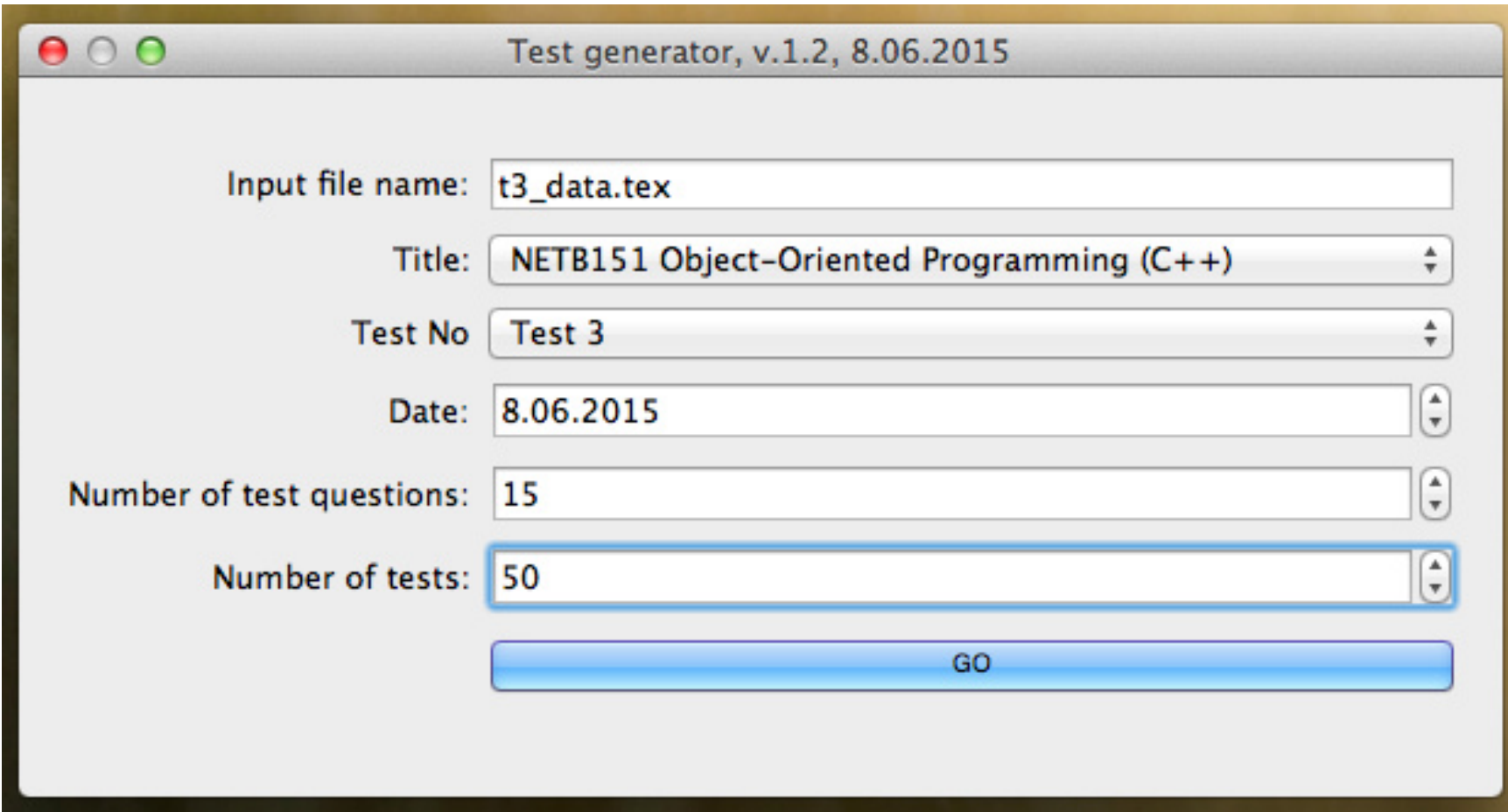
According to a definition by Linn, Davis and Bell, **inquiry** is the intentional process of diagnosing problems, critiquing experiments, distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments.

inquiry		B	D	A
diagnosing problems	understanding the item	+	+	+
critiquing experiments	using compiler	+	+	-
distinguishing alternatives	comparing options	-	+	+
planning investigations	How to search?	+	+	-
researching conjectures	yes, no, nothing	+	+	-
searching for information		+	+	+
constructing models	programming	+	-	-
debating with peers		+	-	+
forming coherent arguments		-	-	+

## *Test generator*

- Preparation of the test begins with selecting items – stems and options and put them into **item bank** [f].
- At least 10 items each having at least 5-6 possible answers should be completed and stored as a text file in a particular format. This file is the input to `test_generator`.
- `test_generator` generates **individual tests** using random distribution of both items and their options [p].
- Each individual test consists of 10-20 items with 4 options (a, b, c, d).
- The output plain text file (`out.tex`) (in  $\text{\LaTeX}$  format) contains all individual tests [f].
- The second output file (`tab.tex`) is a table for checking the tests [f].
- The third file (`data.tex`) is a copy of the input file with additional data for the generated individual tests [f].

## *Test generator*



The screenshot shows a window titled "Test generator, v.1.2, 8.06.2015". It contains several input fields and a button:

- Input file name:** A text box containing "t3\_data.tex".
- Title:** A dropdown menu showing "NETB151 Object-Oriented Programming (C++)".
- Test No:** A dropdown menu showing "Test 3".
- Date:** A text box containing "8.06.2015".
- Number of test questions:** A text box containing "15".
- Number of tests:** A text box containing "50".
- GO:** A blue button at the bottom.

## *Test checker*

Checking test can be carried out:

- manually – using the table (`tab.tex`) generated by `test_generator` [p] or
- automatically – by `test_checker`.

Uploading data on the students' answers can be done:

- manually – using the user interface of `test_checker` or
- automatically – using a special template for students' answers and scanner [p].

The program creates a text file (`save.txt`), containing audited tests [f].

## Test checker

Test checker, v.1.2, 8.06.2015

Test 7764 1

a)

a) ☒ 0 ☐ yes ☐ no 0

b)

b) ☐ 0 ☐ yes ☒ no +

c)

c) ☐ 0 ☒ yes ☐ no -

d)

d) ☐ 0 ☐ yes ☒ no +

Total 1 Quest 1

Exam 20 Points 1

Load Save

Calculate

## Test checker

After entering the students' answers, `test_checker` gives the results – for each option of each item in the test bank calculates two sets of numbers (file `data_result.txt`) [f]. The set  $A = \{a, a_1, a_2, a_3\}$  represents all the tests and the set  $B = \{b, b_1, b_2, b_3\}$  represents the individual tests of students, which pass the test ( $e > 2$ ).

- $a, b$  – the number of individual tests which contain the corresponding item and four of its options;
- $a_1, b_1$  – the number of tests without response;
- $a_2, b_2$  – the number of tests with correct response;
- $a_3, b_3$  – the number of tests with incorrect (opposite) response.

$$a_1 + a_2 + a_3 = a, b_1 + b_2 + b_3 = b, b \leq a \text{ and } b_i \leq a_i \text{ for } i = 1, 2, 3.$$

The output files of `test_checker` are `data_result.txt` and `data_result1.txt`, the format of the second file is suitable for input in spreadsheet.

## *Analysis of the test – example*

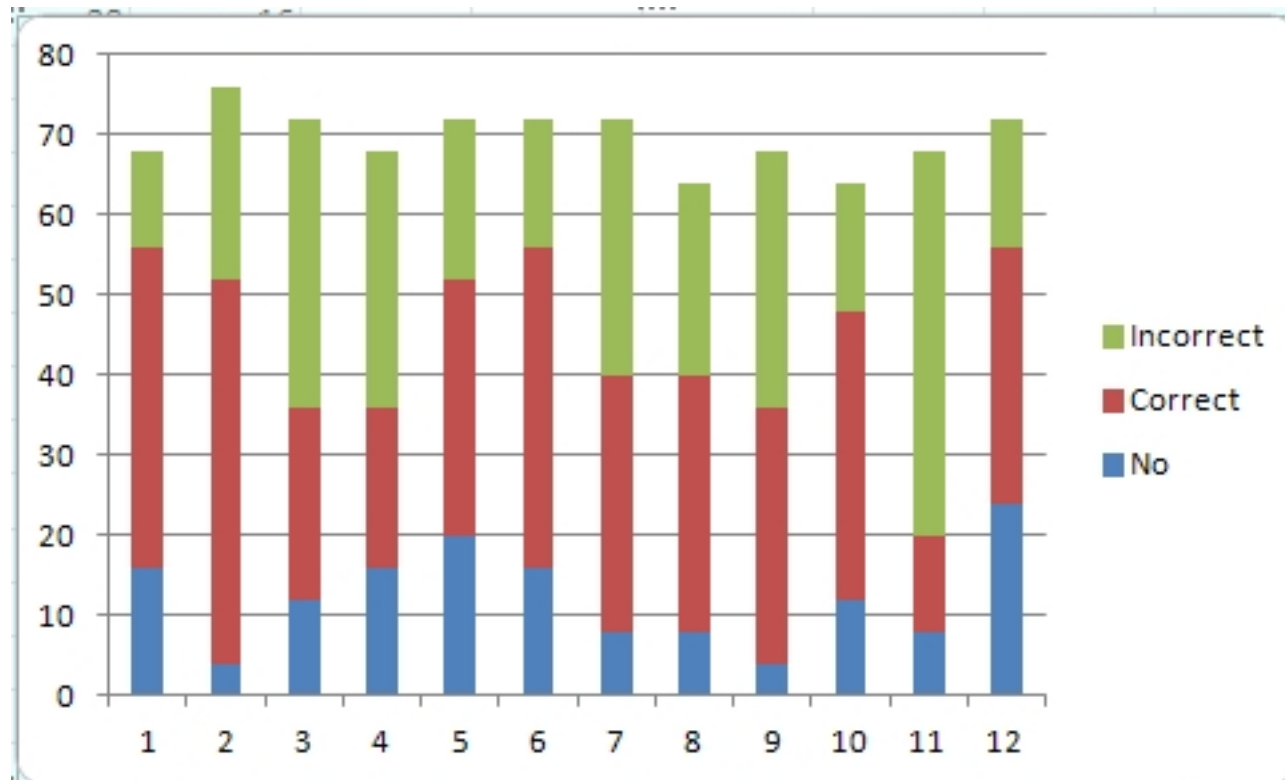
First test of Object-oriented programming (second semester), NBU, program "Network Technologies"

- Test bank consists of 12 item.
- The numbers of options are: (14,16,19,16,12,7,12,16,10,9,16,22).
- Any individual test consists of 11 items (maximum 44 points).
- We have 19 individual tests.

## *Analysis of the test – example*

Items for 19 individual tests – X items, Y results.

- Incorrect – the number of tests with the incorrect (opposite) response.
- Correct – the number of tests with the correct response.
- No – the number of tests without response.

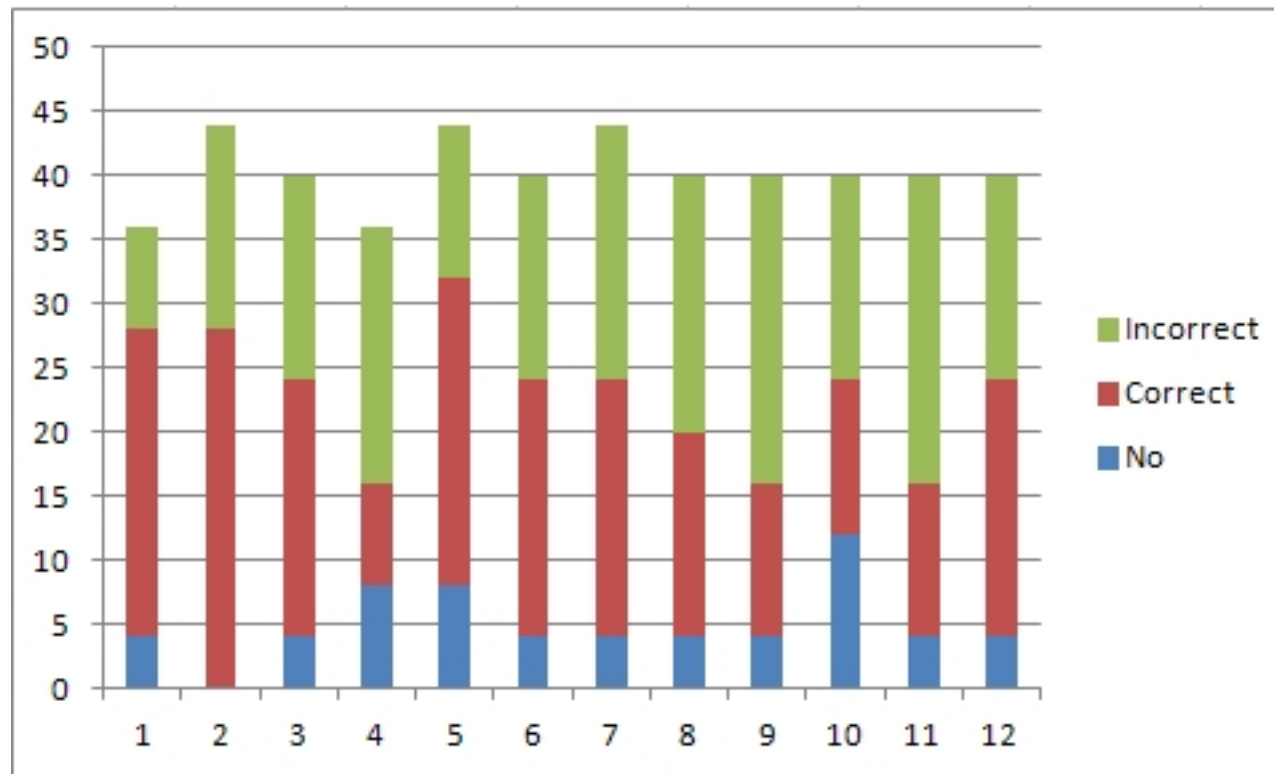




## *Analysis of the test – example*

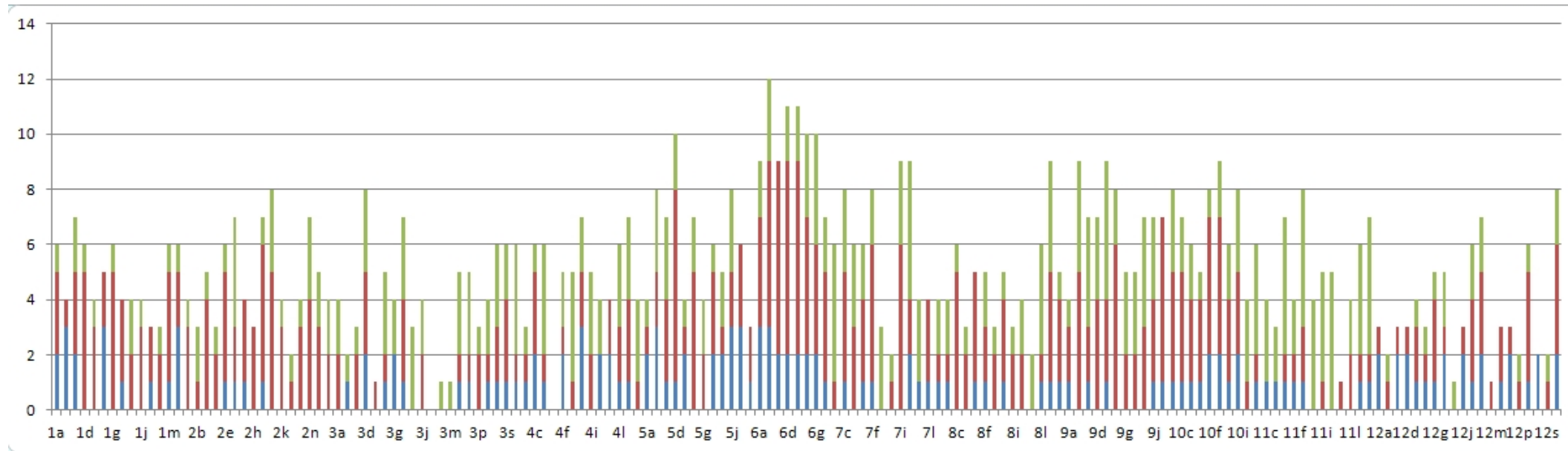
Items for 11 individual tests, which are collected at least a half (22) of maximum points (44).

- Incorrect – the number of tests with the incorrect (opposite) response.
- Correct – the number of tests with the correct response.
- No – the number of tests without response.



## *Analysis of the test – example*

Options for 19 tests: X – options, Y – results.



## *Conclusion*

The software is written in C++ using Qt – cross-platform application and UI development framework (<http://qt.digia.com/>). It is publicly available and **open source**:

- [https://github.com/nkirov/tests\\_generator](https://github.com/nkirov/tests_generator)
- [https://github.com/nkirov/tests\\_checker](https://github.com/nkirov/tests_checker)
- The software is used in undergraduate programming courses for several years.
- save a lot of time and effort of the teacher for the preparation, verification and evaluation of test results.

Using the textbook, course materials and computers during the test, impossibility of cheating and communication with the instructor combine evaluation of knowledge with elements of learning process.

`github.com/nkirov/tests_generator`

`github.com/nkirov/tests_checker`

**Thank you for your attention.**

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