3 COLLECT AND TABULATE DATA

The data was collected using parallel pre- and post-tests administered before, during, and after the unit of instruction. The tabulated data allows both an analysis of student learning and an assessment of the instruments used to measure that learning (i.e., the pre- and post- tests). Both analyses are needed because gains or deficit in

student learning should not be ascribed on the basis of a suspect measurement instrument.

3.1 Develop and Administer Assessment

The primary unit of instruction on iteration that we sought to improve took place over three consecutive class days. During this time the students were using a block-based programming language. Following this unit, the students transitioned to using a text language (Python) when they also learned a more complex data structure (lists of dictionaries). and used iteration to process such data. We were interested in assessing the students learning within the block-based portion and also the transfer of this learning to the text-based portion. Therefore, multiple tests were constructed to assess student learning at different stages.

Each test has nine multiple choice questions and one free response programming question. In this paper we will focus only on the multiple choice questions. The ordering and content of the multiple choice questions remained the same, but the details of the questions (e.g. summing distances vs. summing prices) and the ordering of the answer choices changed between tests. The tests were administered in an online format via a learning management system where each question was presented one at a time, with students not being able to go back to a previous question. This format was used because later questions in the test can give away answers to previous questions in the test (e.g., the code in a later question could give the answer to an earlier recall question).

The assessment consisted of one pretest and three post-tests. A pretest was given at the end of the class prior to the unit beginning. The pretest established each student’s baseline knowledge on the material being taught. The first post-test, sometimes called an embedded post-test, was given at the beginning of the third day of instruction. The second post-test was given two class days after the first post-test. The first two post-tests assessed the student learning within the block-based language portion and used a block-based representation of code for the questions and answer choices. The third post-test, sometimes called a far transfer test, was given eight class days after the second post-test. This post-test was administered after the students had completed the Python coding portion of the class and was administered using the text representation for questions and answer choices. This post-test assessed the transfer of the student learning from the earlier instruction in a bock-based form to a text-based form.

The tests were administered over two sections of the class that each met twice a week. The number of consenting participants were a total of 67 for the pretest, 75 for post-test 1, 72 for post-test 2, and 69 for post-test 3 with 55 students participating in all three tests.

All tests were planned to be administered in class. However, an issue with the learning management system for one section necessitated the pretest for that section to be administered as a take home test. To insure that the difference in pretest administration did not invalidate the pretest we conducted an independent 2-group Mann-Whitney U test between the two sections. The p-value of 0.8157 suggests that there were no significant differences caused by taking the test at home instead of in the classroom.

5 CONCLUSION

In this paper we have presented a pragmatic method for improving instruction by combining knowledge components from a cognitively-based framework with selected steps from a commonly referenced model of instructional design.

This four-step method begin by developing an assessment of the instruction targeted for improvement. In this step, a limited number of formal and informal methods are combined to define the high-level goal of the instruction, break-down the instruction into a set of related steps (visualized in an instructional diagram), identify student’s misconceptions using whatever means are at hand – including experienced observation, and use all of this information in a deliberate way to create assessments that can be directly related to the instruction. We have reported our own experience on using this method to develop an assessment for a unit of instruction on collection-based iteration.

The second step applies the assessment during the teaching of the material and tabulating this data to derive measures of performance, learning gain, difficulty and discrimination. Calculating these measures is straightforward and does not require statistical sophistication. We have reported our experience explaining how we structured our assessment test to gain measures during the primary class days when the material was presented in a block-based language and also a later test to gauge the transfer of this learning to a text-based language. We encountered the usual situation where the administration of one of the tests did not go as planned and we discussed how we recovered from this problem.

The third step analyzes the assessment data to identify weakness in the instruction and specific “knowledge components” that students have not sufficiently mastered. We reported our efforts to relate the assessment to improving the questions on the assessment itself and how one question pointed us to an area where we could improve out instruction.

We are now in the process of performing the fourth step – improving the instruction and improving the assessment.

We have shown how we have applied this method to our instruction of collection based iteration in a computational thinking course. We hope that this work better informs the community about the possibility of using principled

methods to assess and revise critical topics with reasonable level of effort.