

Compelling Test Design Technology: Discrete Option Multiple Choice



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Dear colleagues and friends,

A little over twenty years ago I was heading up a test development team at Novell where we launched the first information technology certification. One of the unique features of the certification exams was that they were computerized adaptive tests (CAT), meaning that every candidate saw a relatively small and different set of questions depending on how he or she answered them. Among other advantages, CAT enhanced the security of the exams by reducing the rate at which each question was exposed.

Over a decade later I had one of those "Aha!" moments in the shower that prompted me to jump out and begin recording my ideas. I was pondering how the exposure-limiting benefit of CAT could also be applied at the item level. Specifically, I was wondering if there were a way to present a multiple choice question to avoid showing all of the options at the same time, but still gather enough information to determine if the person knew the answer to the question. Perhaps because of my experience with adaptive testing, it came to me suddenly that options could be presented one at a time until the person made a mistake or recognized the correct option. This item design seemed somewhat CAT-like to me. The concept then built quickly from there. I thought that this might have real value to an industry that relied so heavily on multiple choice items.

Recently, after a few years of development, I mentioned to my colleagues at Caveon that the Discrete Option Multiple Choice (DOMC) design, as it came to be called, may end up being one of the most helpful of the outcomes of our efforts to computerize the testing industry. The DOMC format applied to multiple choice questions may help alleviate some intractable security, measurement and fairness problems we all deal with every day.

I invite every testing program that uses multiple choice questions (which is just about all of them I believe) to try this new approach. Compared to the benefits, the effort will be minimal. I'm willing to help out as much as possible with detailed specifications, suggestions based on experience, and personal assistance. Questions about DOMC can be directed to my email (david.foster@caveon.com).

Warmest regards,



Introduction

The Discrete Option Multiple Choice question format (DOMC) may be one of the most important testing innovations our industry has experienced in several decades. What makes it so important? There are many compelling reasons, and here are a few good ones:

- It prevents or deters many types of test fraud that are damaging every testing program.
- It promises a more accurate and useful test score, which is a common goal in our industry across all programs. The better the test score, the better are our decisions that are based on that score.
- It saves a lot of money in test development and test security costs.
- It effectively addresses many arguments against multiple choice questions.
- It helps alleviate the unfairness of some testing practices.

These and other benefits are explored in the Advantages section to follow.



**Using Discrete
Option Multiple
Choice results in a
more accurate and
useful test score.**

What is DOMC?

The Discrete Option Multiple Choice (DOMC) question format represents a relatively simple but very useful change in the delivery of multiple choice item content on computerized tests. Instead of providing all of the options at one time to the test taker, as is usually done, options are randomly presented one at a time along with YES and NO buttons. Please see the example below. For each presented option, the test taker chooses YES or NO as to whether the option is perceived as correct or incorrect, respectively. When the question is answered correctly or incorrectly, additional presentations of options are rendered unnecessary.

What is DOMC, continued

Traditional Multiple Choice Test Item:

Q. If $5x + 32 = 4 - 2x$,
what is the value of x ?

- (A) - 4
- (B) - 3
- (C) 4
- (D) 7
- (E) 12

The correct answer is (A) - 4.

(Source: Sample test item for Graduate Record Exam obtained from ets.org.)

Discrete Option Multiple Choice Test Item with one option randomly displayed:

Q. If $5x + 32 = 4 - 2x$,
what is the value of x ?

12

YES

NO

Here the test taker would be expected to click on the NO button as a correct response. Depending on the test taker's response and the random selection of options, the correct option or the other incorrect options may be displayed one after the other, replacing the earlier selection each time.

For the rest of the paper, it is important for the reader to discern the difference between the term "response" and the term "option." A correct option is one that has been written or produced by the item developer and keyed as correct. Option - 4 in the example above is a correct option. The other four options in the example are incorrect options. Using the DOMC approach, a correct "response" is given by the test taker when clicking on the YES or NO buttons, depending on the option presented.

For Example:

Q. If $5x + 32 = 4 - 2x$,
what is the value of x ?

-4

YES

NO

Answering YES when the option - 4 is displayed is a correct response, but so is answering NO when option 12 is displayed. An *incorrect* response is answering NO when option - 4 is displayed or by answering YES when the incorrect option 12 is displayed. Providing one or more correct responses is required to answer the question correctly. Providing even a single incorrect response, whether by clicking the YES or NO buttons, will cause the entire question to be scored as incorrect.

Variations of DOMC

The simplest version of the DOMC test item shown above can be modified in many ways for psychometric, security, or business purposes, just as the typical multiple choice item can be varied for similar reasons. The following significant variation examples are discussed below.

1. Allowing more than one YES response to correct options.
2. Scoring the test item as correct by using NO responses to incorrect options.
3. Presenting only a single option, correct or incorrect, and then scoring the test item.
4. Increasing the number of correct and incorrect options, and
5. Presenting one or more non-scored options after the item has been scored.

1. Allowing more than one YES response to correct options. This allows the item developer to place a more stringent demand on the test taker: For this example, requiring two correct answers instead of one may make an item more difficult and fit a test specification better. Here is an example of the item source content.

Q. STEM: Is this a prime number?

OPTIONS: 29*
 43*
 67*
 87
 39
 63
 51

Those with the asterisk are correct options. Options are presented randomly. When two correct options are eventually displayed and the test taker answers YES to both, the question would be scored as correct.

2. Scoring the item as correct by using NO responses to incorrect options. A NO response to an incorrect option is a correct response, providing information about the test taker's competence, but probably not as much as providing a YES response to a correct option because the NO response is an indirect correct response. Nevertheless, several indirect correct responses can be used to score the item. Consider the prime number item above. If the test taker saw the last 4 options (all non-prime numbers and incorrect) and correctly identified them as not being prime numbers, it may be reasonable psychometrically to score the question as correct even though no prime number was actually displayed.

3. Presenting only a single option, correct or incorrect, and then scoring the item. For some test taking populations, such as small children or individuals with cognitive impairments or test anxiety, the simplest version of DOMC—asking for only a single response to a single option—may remove any negative effects of repetitively presenting a number of options at a time. This variation may then require a larger number of questions/items on the test. This use of a DOMC item also may work well for individuals who are English language learners (if the test is in English) or individuals who may be unfamiliar with how multiple choice tests work.

4. Increasing the number of correct and incorrect options per question. SUPER-DOMC items can be created by supplying each question with greater numbers than usual of both correct and incorrect options, while not manipulating the number of options shown to a specific individual. As the number of options increases the chance that multiple test takers will see the same options decreases. Increasing the number of options improves the item's security value and extends its long-term usefulness. For example, consider an item which requires the addition of two digit numbers:

Objective: Add two digit numbers.

Q. STEM: Is the number statement true?

OPTIONS: $11 + 27 = 38^*$
 $37 + 55 = 92^*$
 $47 + 18 = 65^*$

...hundreds of *correct* options could be added

$35 + 72 = 108$
 $17 + 71 = 98$
 $45 + 45 = 80$
 $61 + 71 = 142$

...hundreds or thousands of *incorrect* options could be added

It also is true that such a question, particularly if all possible correct and incorrect options were part of the item, may be the only item needed for the objective, and the item can even be repeated during a test. It is likely that the SUPER-DOMC item cannot be functionally stolen or shared to help someone cheat. For these reasons, the item may never need to be replaced.

5. Presenting one or more non-scored options after the item has been scored.

This is a good practice for two reasons: (1) immediately terminating the presentation of options when a correct YES response or an incorrect NO response is provided potentially exposes the item's correct answer to the test taker, and (2) displaying additional non-scored options provides psychometric and measurement

information concerning newly produced prospective options. As more experience is gained with the DOMC item, it is anticipated that other psychometric and security benefits may be derived from presenting additional non-scored options after the item has been answered. For example, such a practice could be used when there are indications that the item has been disclosed to measure the extent of compromise and which test takers have been using disclosed content.

Try It Out

The DOMC item with its variations is best understood by trying it out. The reader is invited to go to trydomc.com and select Sample Tests from the menu. Brief tests covering a wide range of topics have been created. A sample test should be taken multiple times in order to learn how items and the test appear differently each time, while scoring remains consistent.

**Discrete Option
Multiple Choice is
best understood by
trying it out. Go to
www.trydomc.com
and select Sample
Tests.**

For each item presented on the practice tests, there is an Item Inner Workings button, which presents details unique to the item. Clicking on the Item Inner Workings button will give you this information:

- The number of correct and incorrect options that were created for the item,
- How many of those options, both correct and incorrect, are randomly selected and scheduled to be presented during the test,
- How the scoring has been set up for the item, and
- The probability of a random additional unscored item.



Psychometric Foundations of DOMC

It is natural to wonder whether the DOMC format will perform as well in a test as the time-honored, century-old traditional format. There are several ways to look at this concern. The first is whether multiple choice items in the DOMC format can combine to produce a reliable test score, which is a well-known strength of the traditional multiple choice format and a critical psychometric standard. An important study by Kingston, et al. (2012) using directly comparable conditions demonstrated that test reliability was not diminished by use of DOMC and may even have been slightly enhanced. Furthermore, the researchers went on to show that using the DOMC item did not add complexity and was not measuring a newly introduced construct. Those results are good news at the test level. But what is happening at the item level?

One enduring fact emerging from studies on the DOMC (Foster & Miller, 2009; Kingston, et al., 2012; Willing, 2014 in press) is that the test becomes more difficult, reflecting the combined increase in difficulty of most of the items. The most likely explanation at this point is that by removing the influence of test taking skills, the items and test will demonstrate a heightened, but realistic, degree of difficulty.

A review of the item discrimination statistics provides a bit of a mystery. Overall the studies show that average item discrimination does not change much between DOMC and the traditional form; however, looking at individual items reveals idiosyncratic differences (Foster & Miller, 2009). That is, for some items, the discrimination value (e.g., point biserial, correlation) is higher for DOMC, but for others it is lower. This effect is grist for the research mill and may lead to new ways of viewing how we write items, both traditional multiple choice and DOMC.

One research result interesting to psychometricians is that tests take less time to complete when the items are administered in DOMC format. This time savings has ranged from 10% (Foster & Miller, 2009) to almost 40% (Willing, et al., 2014 in press). While the reasons for this time savings are currently not well understood, the savings is intriguing, has obvious practical benefits, and may provide new insight into how test takers process and provide responses to test questions.

Some psychometricians are concerned that test takers do not have the same experience when the same item is presented in the DOMC format. This is true. The correct option may never be shown; options are presented randomly; some test takers may see a single option, others may see three or four. In every case, the experience is made more similar by presenting the same stem, and there is the same effort by the test taker to determine the answer by himself or herself. Looking at this concern another way, it is reasonable to assume that test takers do not experience the traditional multiple choice test item in a consistent way either. Despite how test



developers write and present the items, it is well-known that test takers read and review individual questions differently from one another. Some may first review the options before reading the stem. Others may skim the stem first, then the options, then re-read the stem and options more carefully. Some may read the options from A to D, while others read them in the opposite direction. My most common strategy in my test-taking days in school was to read the stem well, determine my best answer, and then run through the options quickly until I found the answer that matches the one I produced. Once I did, I selected that answer and didn't bother to read the rest. What is clear from the research on how people read and answer multiple choice test items is that no standard way of responding to a test item is followed. Due to the inherent variability in responding to traditional multiple choice test items, it is possible that the DOMC may actually provide a more standardized and controllable approach to presenting question content.

Other exciting projects in our field are dealing with similar issues. The concepts of Automatic Item Generation (AIG; Gierl & Haladyna, 2013) and Item Families (Geerlings, van der Linden & Glas, 2012) are based on models that use a small set of statistical properties to represent a large number of items that differ from each other in minor or major ways. Using the DOMC format can perhaps be viewed as implementing a version of AIG, creating items on-the-fly according to clear and consistent rules. Or the many ways an item appears to test takers may be considered part of that "item family."

Based on study results, there appear to be no psychometric reasons for excluding DOMC from testing programs.

There is no arguing that the DOMC is a new and exciting format and that it needs an enlarging base of users and research, particularly given that it is challenging a 100-year-old method, that is rarely criticized except by critics of all standardized tests. The several studies on DOMC conducted so far are encouraging. Kingston, et al. (2012) concluded that, "Based on the results of this study, there appear to be no psychometric reasons for excluding DOMC from testing programs" (p. 15). As DOMC gains in use, academicians and practitioners will provide more research-based answers to help us better utilize this new approach.

DOMC Advantages Compared to Traditional Multiple Choice

The advantages of the DOMC are divided into several categories and presented in the table below. Where there is research supporting the advantage, a research study is noted. Support for the other advantages awaits further research. Each advantage is preceded by a rating provided by the author based on the author's experience. They serve to help organize the advantages and may not reflect the experiences or expectations of individual testing programs.

Author's Ratings	Author's Assumptions
Major	May have significant positive impact on current measurement challenges having to do with efforts to improve test accuracy, enhance test security, provide greater fairness, reduce test administration time, and reduce costs.
Moderate	Impact may be noticeable and appreciated; perhaps critical in some cases.
Minor	Miscellaneous important benefits. Consider these to be "icing on the cake."

DOMC Security Advantages

Rating	Advantage	Explanation	Research Support
Major	Exposure ¹ of item content is reduced significantly.	On average, only about 2.5 options are shown to the test taker when an item is displayed. As the number of options increases in the option pool, the exposure rate per option decreases.	Foster & Miller, 2009; Willing, Ostpczuk, & Musch, 2014 in press; research is needed to quantify the improvement to test security.
Major	The reduced exposure of item options interferes with piracy and cheating efforts.	It is very difficult to steal test questions or use stolen questions to cheat when each time a multiple choice test item is presented, only a small percentage of the options are seen. Test theft efforts will be significantly impacted if DOMC is used.	Research is needed to demonstrate how reduced content exposure disrupts test cheating and theft activities.
Minor	The DOMC format will reduce a person's motivation to cheat.	Test takers cannot predict what options they will see for any item during the exam. They will not trust any source that purports to provide pre-knowledge about the items and answers.	Logical argument, but research is needed.
Minor	The DOMC format can be used to reinstate or re-vitalize a compromised or exposed test or item pool.	Item banks or tests that have been retired due to known compromise or have reached an exposure limit can be re-used as DOMC items, perhaps with some options added to each item.	Logical argument, but research is needed.
Minor	DOMC takes the security risk out of public review of items.	There are psychometric problems and security risks created when the public, including lawyers, parents and educators, are able to view test questions before or after they are used in a test. DOMC questions, particularly the SUPER-DOMC variety, should be more resistant to the negative effects of reviews than are those of traditional items.	Logical argument, but needs research support.

¹ Item exposure refers to the number of test takers who have seen the content or the number of times the item content has been displayed.

DOMC Measurement Advantages

Rating	Advantage	Explanation	Research Support
Major	DOMC results in more meaningful and useful test scores due to the removal of irrelevant measurement.	A priority for psychometricians is to reduce construct-irrelevant variance (CIV) ² in tests. The DOMC removes a major source of CIV resulting from testwiseness (using test taking skills) inherent in traditional multiple choice items.	Foster & Miller, 2009; Willing, Ostpczuk, & Musch, 2014 in press
Moderate	DOMC provides about 2.5 times more information from each test taker per item.	Test takers respond to both correct and incorrect options when answering an item, providing additional information about the test taker. The information can be used to craft better scores or to evaluate the tests and items more effectively.	Foster & Miller, 2009
Moderate	Improved accuracy of psychometric statistics from DOMC contributes to better decisions.	Difficulty and discrimination indices are less affected by CIV.	Foster & Miller, 2009; Kingston, et al., 2012
Moderate	DOMC reduces effects of guessing, both “educated” and random.	DOMC removes the effects of educated guessing, which is using test taking skills. Random guessing is still possible, although its effectiveness decreases rapidly as more options are written for each item.	Foster unpublished research, (2009)
Minor	Using DOMC invalidates some criticisms of multiple choice test item use.	Criticisms of traditional multiple choice test items that refer to test preparation effects are valid. DOMC eliminates the effectiveness of those criticisms.	Logical argument supported by Foster & Miller, 2009; Willing, Ostpczuk, & Musch, 2014 in press
Minor	DOMC may widen the range of content areas considered for objectively scored tests.	DOMC can serve as an easy-to-use “response-gathering” mechanism to be used with complex performances required by the stem.	Logical argument that needs research support.

²The score on a multiple choice test represents more than just the test taker’s ability to recall the right knowledge (or other skills), but it also represents the unwanted measurement of other skills, such as the test taking skills gained with years of experience taking such tests or taught explicitly by test preparation services. The unwanted portion that is unfortunately being measured is called Construct-Irrelevant Variance or CIV, meaning in this example that test taking skills are irrelevant to the construct or content intended to be measured by the test. No test intends to measure such skills. It is the ethical responsibility of psychometricians to remove sources of CIV so that the test score more accurately reflects the skills intended.

DOMC Fairness Advantages

Rating	Advantage	Explanation	Research Support
Major	DOMC removes inappropriate advantages that some test takers have.	This advantage comes from two sources. First, test taking skills are often associated with individuals who can afford expensive test preparation. The DOMC item removes the effects of that training, effectively leveling the playing field. Second, because traditional multiple choice items are more susceptible to theft and cheating, honest test takers are at a distinct disadvantage. DOMC removes that unfairness as well.	Logical argument, but research is needed.
Major	The DOMC format expands the reach of fair multiple choice testing to other populations.	Young children, older persons, persons with test anxiety or who lack test taking prowess, test takers where the language of the test is not their native language, individuals who are culturally not as familiar with traditional multiple choice test items, and others, find the DOMC format to be less complex, making the understanding of and responding to the question a simpler and more straightforward task.	Unpublished research by Foster found that young children could complete a test using DOMC, but were not able to when traditional multiple choice items were used. Foster & Miller (2009) reported that university students recognized the enhanced fairness of DOMC.

Item/Test Development Advantages

Rating	Advantage	Explanation	Research Support
Major	DOMC cuts test development costs.	Because of improved security, items remain in service longer, perhaps indefinitely. This reduces test development costs related to the replacement of items.	Logical, but research is needed to determine the actual cost savings.
Moderate	Existing item banks and tests can be converted easily to DOMC.	Traditional multiple choice items usually need no modification to work as DOMC items. Some only need minor re-wording.	Foster unpublished research (2009)

Test Delivery Advantage

Rating	Advantage	Explanation	Research Support
Moderate	DOMC will result in reduced test administration costs and increased testing channel capacity.	The less time (10% to 35%) required by the DOMC item will result in tests of shorter duration, and therefore reduced cost, of test administration. Organizations with test administration channels can expect increased capacity for this same reason.	The time savings is supported by research: Foster & Miller, 2009; Willing, Ostpczuk, & Musch, 2014 in press. Research is needed on how this affects test administration.

Learning and Motivational Advantages

Rating	Advantage	Explanation	Research Support
Moderate	Students and candidates are motivated properly to learn and prepare for the test.	The DOMC item requires a more confident and certain ability to recall relevant knowledge learned or to demonstrate other cognitive or behavioral skills. At least one set of researchers found in students increased levels of self-efficacy, along with a greater perceived value of the courses associated with DOMC.	Samuel & Hinson, 2012

Some Challenges Using DOMC

The many advantages listed in the previous section do not come without some effort and challenges. Test taker preparation is important, along with some training for item writers and changes to testing software systems. Here are a few challenges that can be expected, none of which are particularly unique to DOMC.



- **The DOMC format is unfamiliar.** The DOMC is different enough from the usual format that it takes a bit of practice to gain familiarity. However, compared to other new item types, the format is intuitive and easily learned (Foster & Miller, 2009). Practice tests using the method are easy to produce and make available.
- **The DOMC is not a preferred multiple choice format for test takers.** The DOMC is not appealing to most test takers, especially those who believe they have strong multiple choice test taking skills (Foster & Miller, 2009). Providing education on the benefits of the DOMC, most of which apply directly to the test taker, can help to overcome this objection.
- **The DOMC is not a replacement for ALL multiple choice test items.** The DOMC format may not work well for the true “choose the best option” item type. The accurate version of this item type is where all of the options are correct, but one is more correct than the others. While many traditional items ask for the “best” answer among the options, the options are written to have one correct answer with the rest being incorrect. The true “choose the best option” question is very rare, fits few test objectives, and is very difficult to produce. A review of the content of test preparation guides for the largest testing programs in the world revealed that less than 5% of items are of the “choose the best option” type, and most programs do not use it at all. If such items are in the item pool, those items should continue to be presented in the traditional format.
- **DOMC options must be clearly correct or incorrect.** The DOMC format places a greater demand on a test developer to create items with options that are clearly correct or clearly incorrect (which is, of course, a standard practice even for traditional multiple choice test items). Poor item writing is never acceptable.
- **Current item banking, test publication, test administration, and test results storage systems need modification to accommodate DOMC.** This is generally the case with the introduction of any new item type.

- **The DOMC format requires a forward-only item delivery model.** DOMC items, like items delivered in adaptive tests and other test designs, cannot be reviewed again during an exam.
- **Initial costs to develop SUPER-DOMC items may be higher from a test development perspective than creating the typical multiple choice item.** This is due to the effort to create additional correct and incorrect options.
- **It is not possible to use the DOMC item type with paper-and-pencil testing programs.** The computer is required to randomize and select options, as well as to score the item on the fly.

Return on DOMC Investment

The return on investment (ROI) for any new innovation should be calculated or estimated using conservative assumptions and figures. Does it make sense to spend the time, effort, and money to implement DOMC into a testing program? Because the advantages are many, with some being hard to quantify, it is difficult to provide examples that are exactly relevant to every testing program and every test administration service provider. Two ROI examples are given in appendices. Appendix B contains the ROI analysis for a small testing program; Appendix C contains the ROI analysis for a large test administration service provider. The examples are naturally incomplete and assumptions are just that—assumptions. A more thorough ROI is encouraged if these do not suffice. These two ROI analyses are helpful in illuminating the various costs and savings available through the use of DOMC.

When reviewing the ROI analyses in the appendices, it will be apparent that not all costs and financial benefits have been included in the examples, although the significant ones have. The general lesson learned from the ROI analyses is that, even with a conservative analysis, the costs to use and implement DOMC are extremely small compared to the increased value and reduced costs resulting from its use.

The costs to implement and use DOMC are small compared to the increased value & reduced costs resulting from its use.

Each program should evaluate its unique circumstances in order to determine how much value can be obtained by replacing its traditional multiple choice test items with DOMC. The license fee to try out the technology in order to determine more accurate assumptions is free.

Patent, Use and Implementation Information

The DOMC item type is patented, and a license is needed to use the item in a quiz, test or exam.

Title: PRESENTING ANSWER OPTIONS TO MULTIPLE-CHOICE QUESTIONS DURING ADMINISTRATION OF A COMPUTERIZED TEST

Inventor: David F. Foster

Publication Number: US-2007-0166686-A1

Publication Date: July 19, 2007

The license fee for the use of DOMC for research and trial purposes is free. For commercial use in operational testing programs there is a nominal fee. License agreements for these uses are available at www.trydomc.com.

Upon signing any of the license agreements, specifications and other assistance will be provided to make it easy to understand how to get started using DOMC. Two test delivery engines already support the use of DOMC. Those organizations are listed in Appendix A.

Conclusion and Recommendations

The DOMC format is a relatively new format that has been designed to address some of the problems with traditional multiple choice questions as well as current and emerging threats to test security. Initial studies on the item type have shown the DOMC is appropriate in many testing situations and can enhance test security while reducing long-term testing costs. Like any format, the DOMC has some limitations (e.g., it is not preferred by test takers); however, overall, it is found to be a promising alternative to traditional multiple choice testing.

Security is a big problem for all, and the DOMC will be most effective against the stealing of test content regardless of the method. However, the method is important. We are entering an era where practically undetectable digital capturing technologies will steal the content from under the noses of proctors (e.g., glasses, pens, etc., with cameras in them). Those devices will be able to relay the test content, even in real time, to others. Item and test design features that protect the content, such as DOMC, may well be the best defense against such tools.



A common criticism of traditional multiple choice questions is that they allow test taking skills to significantly alter the scores, and because of that, they are unfair and biased in favor of those who have or can afford such training. The DOMC format prevents test takers from gaining an advantage through test taking skills rather than from actual competency in the subject matter. More accurate scores will encourage decision making based on relevant competency. In addition, this may lead to a shift in the test preparation industry, encouraging organizations to teach participants the real skills that the test measures rather than “tricks” of multiple choice testing.

Finally, it is anticipated that DOMC will reduce costs significantly for test administration and test development. Because items will not have to be replaced as often, organizations can expect to see long-term cost savings associated with item development. Moreover, some organizations also may see cost savings associated with test administration. Duration of tests using the DOMC format have been shown to be shorter, and this will lead to less time occupying testing facilities, which leads to cost savings.

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Appendix A

DOMC Supporting Organizations³

Organizations with Test Drivers that Support DOMC for both Test Development and Test Administration

Kryterion, Inc. (www.kryteriononline.com) was the first to support the use of DOMC. It has incorporated a limited version of DOMC in its online test development and test delivery engine, Webassessor, allowing only a single correct option and a limited number of incorrect options.

Contact: John Dight, Kryterion
Email: jdight@kryteriononline.com
Phone: 602-659-4687

Excelsoft (www.excelindia.com) supports fully functional DOMC in its SARAS online test development and test delivery platform.

Contact: Dev Ramnane, Excelsoft
Email: dev.r@excelindia.com
Phone: 732-333-2921

Organizations Authorized to Distribute DOMC and to Provide Training and Implementation Support

Caveon (www.caveon.com) is the exclusive United States Distributor of DOMC.

Contact: Steve Addicott, Caveon
Email: steve.addicott@caveon.com
Phone: 435-901-4744

³ As of April 2014

Appendix B

Return on DOMC Investment: Testing Program

The costs of using DOMC can be divided into two main categories: (1) cost of the patent license fee and (2) cost of implementation. The latter involves the following question: “What is it going to cost to change an existing test driver to incorporate this item type?” To answer this, let’s make an assumption about costs for both types of fees:

Costs

Patent License Fee. These fees run from 1.5 cents per test administered to up to 19 cents per test administered (see details in the Commercial Technology License Agreement located at trydomc.com). The pricing scale varies due to a volume-of-tests discount. The greater the number of tests administered, the lower the cents-per-test fee. This fee can be reduced further if an annual license option is chosen, or if educational discounts are merited. For this most-conservative ROI analysis, we can assume the highest fee of 19 cents-per-test for a testing program of less than 10,000 exams a year. For all other programs, the ROI analysis will provide an even better result.

Assumption: 10,000 administered tests a year at 19 cents per test. This equals \$1,900⁴.

Cost of Implementation. Implementation costs are incurred by early adopters to introduce any new item type into an existing test driver. This is true for DOMC, too. However, if a test administration service provider’s driver already supports it, this cost may be zero. Or a test administration service provider may reduce the charge to implement DOMC if they want to offer the item type to other clients. For the purposes of this conservative ROI analysis, a one-time fee of \$45,000 to support DOMC is assumed. For subsequent years, this cost would be zero.

Assumption: New implementation in existing test administration service provider’s driver or program’s own test driver: \$45,000 first year of use.

For the purposes of this analysis, we will consider two types of ROI Areas: (1) those that are quantifiable and (2) those that are not easily quantified but nonetheless contribute to the value of using the DOMC item type. Quantifiable ROI Areas include reduced test development costs for additional items to support security purposes; reduced test development costs due to increased operational shelf-life for tests; and reduced test administration times. Non-quantifiable ROIs include reputation value lost when a breach occurs and improved accuracy and value of the test scores. The non-quantifiable ROIs were not included in the total cost savings calculations because their assumptions are more difficult to establish with any accuracy. However, the reader is encouraged to review them to understand how DOMC might affect the value of a program’s reputation and how the program might benefit from increased confidence in the accuracy of test scores.

Quantifiable ROI Areas

- **Item development costs for security purposes.** This includes additional items created to expand adaptive item pools, for additional test forms, or for forms to be used in the event of a breach. The use of DOMC eliminates the need to create additional items for security purposes, so this can be viewed as an annual cost savings.

⁴This fee may not be paid as a license fee if DOMC is supported by a program’s test administration service provider and the cost is simply part of the normal test administration fee, as is the case for most or all other item types that are included in the test driver.

We can probably assume that double the number of original items need to be created. At a conservative calculation, if 150 additional items need to be created, at an estimate of \$100 each, the total “security” cost is \$15,000.⁵

First year item development savings using DOMC = \$15,000, as this cost to create additional items for security purposes is eliminated.

- **Increase in operational shelf-life for items.** We can conservatively assume that items will be able to remain in service twice as long as traditional items. That would mean that an entire test development cycle could be avoided. If the cost of developing the original test was \$75,000, including all aspects of that development, then the savings would be \$75,000.

Savings of \$75,000 spread over two years = \$37,500 annual savings.

- **Savings due to reduced test administration time.** Tests are usually administered in computerized testing circumstances on the basis of scheduled time at a center. Conservative estimates of time savings using DOMC is 10%. One set of researchers found almost 40% savings. If we assume that only a 10% savings will be seen, and that it costs \$50 to administer each of the program’s 10,000 tests, then the savings would be \$50,000 each year (10% of \$500,000 annual test administration costs).

Savings of \$50,000 each year in test administration costs.

If you wish, you can skip to the Summary section, as it does not include the two “Non-Quantifiable ROI” areas below. They were not included because their assumptions are more difficult to establish with any accuracy. Nevertheless, the reader should review them to understand how DOMC might affect the value of a program’s reputation and how the program might benefit from increased confidence in the accuracy of test scores.

Non-Quantifiable ROI Areas (not counted in ROI Analysis)

- **Reputation value.** This is very hard to estimate, but it can be assumed to be the highest value asset of the program. Some organizations may value their reputation on the order of millions or more.
- **Improved accuracy and value of test scores.** Being able to make better, more accurate decisions with your test scores results in fewer problems later on as a greater proportion of qualified individuals enter the workplace or succeed in college.

Summary of ROI Analysis for a Testing Program

The cost to license and implement DOMC in this hypothetical small program is \$1,900 + \$45,000 for the first year, and \$1,900 each year after that. The savings to the program is estimated to be \$102,500 each year that DOMC is used. As this was a conservative estimate using an example of a smaller program, larger testing programs would likely experience an ROI that would be significantly greater.

⁵This is a low estimate of per-item development costs. For some testing programs, item development costs may run well over \$1000 per item. This ROI estimate is intended to be conservative, so \$100 per item.

Not all costs have been included in this ROI example. Other potential savings from other advantages could be realized depending on the testing program.

The general lesson learned from the ROI analysis is that the costs to use and implement DOMC are very small, even with a conservative analysis, compared to the increased value and reduced costs resulting from its use.

Each program should evaluate its unique circumstances in order to determine how much value can be obtained by replacing its traditional multiple choice test items with DOMC.

Appendix C

Return on DOMC Investment: Test Administration Service Provider

For the test administration service provider, the costs of using DOMC can be divided into two main categories: (1) cost of the patent license fee and (2) cost of implementation. The latter involves the following question: "What is it going to cost to change an existing test driver to incorporate this item type?" So, let's make an assumption about costs for both types of fees:

Costs

- **Patent License Fee.** These fees run from 1.5 cents-per-test administered to up to 19 cents-per-test administered (see details in the Commercial Technology License Agreement located at trydomc.com). The pricing scale varies due to a volume-of-tests discount. The greater the number of tests administered, the lower the cents-per-test fee. This fee can be reduced further if an annual license option is chosen, or if educational discounts are merited. For this most-conservative ROI analysis, let's assume a per-test pricing option and the lowest per-test fee of 1.5 cents-per-test for a test administration service provider providing for more than 3,000,000 tests a year. The test administration service provider receives a "reseller" discount of 40%, dropping the cost further to .9 cents per test. The total annual license fee then would be \$27,000.

Assumption: 3,000,000 administered tests per year at .9 cent per test = \$27,000 per year.

- **Cost of Implementation.** Implementation costs are incurred by early adopters to introduce any new item type into an existing test driver. Test administration vendors introduce new features into their systems each year. The cost to implement DOMC is estimated to be \$45,000, a one-time cost. For subsequent years, this cost would be zero or near zero.

Assumption: New implementation in existing test administration driver: \$45,000 first year of use.

- **Cost of the DOMC Benefit of Reduced Testing Time.** As clients realize that their tests will be shorter, then according to standard seat time payment charts, they will likely end up paying less per test to the test administration services provider. If we assume this value is 10%, then the service provide may expect a 10% reduction in revenue from existing clients. Of course, the additional bandwidth in the testing channel allows for this revenue to be recouped, and the lower costs per test may provide a competitive price advantage over others. Given these assumptions, the assumption is that these costs are compensated by the increased capacity in the channel.

Additional Revenue

The following paragraphs describe the additional revenue a test administration service provider might realize with the use of DOMC.

- **Increase test administration revenue from testing programs.** A test administration service provider could justifiably increase fees by \$1.00 per test due to the substantial savings the client might expect in security, test development, and the many other advantages to a testing program.

At \$1.00 per test, increased revenue from 3,000,000 tests is \$3,000,000 each year, with almost all of that going to the bottom line. This assumes, of course, that most, if not all, of the clients will adopt DOMC for their program in the first year, which is unlikely. But even if only a small percentage do so, the financial value of supporting DOMC remains strong while increasing upside each year as more clients adopt the new item type.

Summary

Not all sources of costs, cost saving, or revenue have been included in this ROI example, although the main ones have.

The general lesson learned from the ROI analysis is that the costs to use and implement DOMC are very small, even with a conservative analysis, compared to the increased value and reduced costs resulting from its use.

Each test administration service provider should evaluate its unique circumstances in order to determine how much value can be obtained by adding DOMC to complete its support for the many varieties of multiple choice test items. The license fee to pilot the technology in order to determine more accurate assumptions is free.