



IBM Cloud Professional Certification Program

Study Guide Series

Exam C1000-144: IBM Machine Learning Data Scientist v1

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Purpose of Exam Objectives

When an exam is developed, Subject Matter Experts work together to define the role the certified individual will fill. They define the tasks and knowledge that an individual would need to successfully perform this job role due the product or solution. This creates the foundation for the objectives and measurement criteria, which form the basis of the certification exam. Question writers then use these objectives to develop exam questions.

It is recommended that you review these objectives and ask yourself the following questions:

- Do you know how to complete the task in the objective?
- Do you know why that task needs to be done?
- Do you know what will happen if you do it incorrectly?

If you are not familiar with a task, go through the objective, perform that task in your own environment and read more information on the task. If there is an objective on a task, there is a high likelihood that you WILL see a question about it on the actual exam. Review the recommended learning designed to prepare you to take the certification exam.

After reviewing the objectives in this guide and completing your own research, take the assessment exam. While the assessment exam does not indicate which specific questions were answered incorrectly, it does indicate overall performance by section. This is a good indicator of preparedness or if further preparation is warranted.

High-level Exam Objectives

Section 1 - Evaluate business problem including ethical implications	
1.1	Understand business requirements
1.2	Understand what data is available
1.3	Understand ethical challenges in the business problem
1.4	Perform AI design thinking
1.5	Assess progress on the AI Ladder
Section 2 - Exploratory Data Analysis including data preparation	
2.1	Identify the methods used to clean, label, and anonymize data
2.2	Visualize data
2.3	Balance and partition data
Section 3 - Implement the proper model	
3.1	Implement Supervised Learning: Regression
3.2	Implement Supervised Learning: Classification
3.3	Implement Unsupervised Learning: Clustering
3.4	Implement Unsupervised Learning: Dimensional Reduction
Section 4 -Refine and deploy the model	
4.1	Identify operations and transformations taken to select and engineer features
4.2	Select the proper tools
4.3	Configure the appropriate environment specifications for training the model
4.4	Train the model and optimize hyperparameters
4.5	Implement the ability for the model to explain itself
4.6	Deploy the model
Section 5 -Monitor models in production	
5.1	Assess the model
5.2	Monitor the model in production
5.3	Determine if there is unfair bias in the model

Detailed Exam Objectives

Section 1 - Evaluate business problem including ethical implications

1.1. Understand business requirements

SUBTASKS:

- 1.1.1. Explain how IBM Garage Methodology works
- 1.1.2. Understand the CRISP-DM process
- 1.1.3. Identify which business opportunity to prioritize and define success metrics for an MVP

REFERENCES:

<https://www.ibm.com/garage>
<https://thinkinsights.net/digital/crisp-dm/>

1.2. Understand what data is available

SUBTASKS:

- 1.2.1. Use SQL to access data
 - 1.2.1.1. Extracting specific columns
 - 1.2.1.2. Filtering data
 - 1.2.1.3. Combining Tables
- 1.2.2. Use Python APIs to access data
- 1.2.3. Scrape information from a website
- 1.2.4. Read data into a Pandas Dataframe
 - 1.2.4.1. Reading different types of data assets
 - 1.2.4.2. Manipulating column names
 - 1.2.4.3. Obtaining specific rows

REFERENCES:

<https://www.w3schools.com/sql/>
<https://realpython.com/python-api/>
<https://www.crummy.com/software/BeautifulSoup/bs4/doc/>
https://pandas.pydata.org/docs/getting_started/index.html

1.3. Understand ethical challenges in the business problem

SUBTASKS:

- 1.3.1. List potential sources of unfair bias
- 1.3.2. List potential sources of privacy violations
- 1.3.3. List potential secondary and tertiary effects of the application
- 1.3.4. Plan to prevent or mitigate negative consequences

REFERENCES:

<https://learn.ibm.com/course/view.php?id=8390>
<https://learning.oreilly.com/library/view/ai-fairness/9781492077664/>
Introduction
https://www.ibm.com/design/thinking/page/courses/AI_Essentials > Clearbridge case study > Reflect on your AI's capabilities
<https://www.designethically.com/layers>
<https://www.ibm.com/design/ai/ethics/>

1.4. Perform AI design thinking

SUBTASKS:

- 1.4.1. Align on user intents for a solution
- 1.4.2. Document the available data

- 1.4.3. Determine what training will be required
- 1.4.4. Create hypotheses about what the behavior of the system will be
- 1.4.5. Assess feasibility and refine if needed
- 1.4.6. Consider direct and indirect effects of the solution

REFERENCES:

https://www.ibm.com/design/thinking/page/courses/AI_Essentials
<https://www.ibm.com/design/thinking/page/toolkit/activity/ai-essentials-intent>
<https://www.ibm.com/design/thinking/static/team-essentials-for-ai-workbook-8dc9aadb2cc2dc6343cc5e420b522ca2.pdf>
<https://learning.oreilly.com/library/view/operationalizing-ai/9781098101329/> --- Chapter 3

1.5. Assess progress on the AI Ladder

SUBTASKS:

- 1.5.1. Assess progress in collecting data
- 1.5.2. Assess progress in organizing data
- 1.5.3. Assess progress in analyzing data
- 1.5.4. Assess progress in infusing AI into the organization

REFERENCES:

<https://www.ibm.com/downloads/cas/O1VADKY2>
<https://learn.ibm.com/course/view.php?id=8496>

Section 2 – Exploratory Data Analysis including data preparation

2.1. Identify the methods used to clean, label, and anonymize data

SUBTASKS:

- 2.1.1. Clean data
 - 2.1.1.1. Fill or drop missing values
 - 2.1.1.2. Remove duplicate rows
 - 2.1.1.3. Remove outliers
 - 2.1.1.4. Converting data types
 - 2.1.1.5. Data normalization
- 2.1.2. Label data
 - 2.1.2.1. Understand the benefits and challenges to labeling data
 - 2.1.2.2. Explain data labeling approaches
- 2.1.3. Anonymize data

REFERENCES:

<https://www.ibm.com/garage/method/practices/reason/prepare-data-for-machine-learning/>
<https://www.ibm.com/garage/method/practices/code/data-preparation-ai-data-science/>

<https://www.ibm.com/cloud/learn/data-labeling>

<https://dataplatform.cloud.ibm.com/docs/content/wsj/governance/dmg22.html>

2.2. Visualize data

SUBTASKS:

- 2.2.1. Choose the column(s) from your dataset to be visualized
- 2.2.2. Identify what the visualization should describe about the column(s)
 - 2.2.2.1. Distribution
 - 2.2.2.2. Correlation
 - 2.2.2.3. Comparison
 - 2.2.2.4. Time Series
- 2.2.3. Select a type of chart based on the descriptive need
 - 2.2.3.1. Histogram/Box plot/Violin plot
 - 2.2.3.2. Scatterplot/Heatmap
 - 2.2.3.3. Bar chart
 - 2.2.3.4. Line plot
- 2.2.4. Select a library or tool for visualization
 - 2.2.4.1. Matplotlib
 - 2.2.4.2. Seaborn
 - 2.2.4.3. Bokeh
 - 2.2.4.4. Plotly
- 2.2.5. Plot the visualization

REFERENCES:

<https://seaborn.pydata.org/introduction.html>

<https://matplotlib.org/stable/tutorials/introductory/usage.html#sphx-glr-tutorials-introductory-usage-py>

https://docs.bokeh.org/en/latest/docs/first_steps.html

<https://plotly.com/python/>

<https://learn.ibm.com/course/view.php?id=8794>

<https://learning.oreilly.com/library/view/statistics-in-a/9781449361129/> Chapter 4

2.3. Balance and partition data

SUBTASKS:

- 2.3.1. Partition data
 - 2.3.1.1. Create train/test/validation splits

REFERENCES:

<https://learn.ibm.com/mod/video/view.php?id=165773> (data leakage mentioned in passing)

- 2.3.1.2. Understand and implement cross validation

REFERENCES:

<https://learn.ibm.com/mod/video/view.php?id=166655>

<https://learn.ibm.com/mod/page/view.php?id=170328&forceview=1>

2.3.1.3. Prevent data leakage

REFERENCES:

[https://en.wikipedia.org/wiki/Leakage_\(machine_learning\)](https://en.wikipedia.org/wiki/Leakage_(machine_learning))

<https://reproducible.cs.princeton.edu/> (this is a common problem)

2.3.1.4. Create data splits that are reproducible

REFERENCES:

<https://cs230.stanford.edu/blog/split/>

<https://learn.ibm.com/mod/video/view.php?id=166646&forceview=1>

<https://learning.oreilly.com/library/view/machine-learning-design/9781098115777/ch06.html#problem-id00022>

2.3.2. Balance data

2.3.2.1. Understand why imbalanced data is problematic

REFERENCES:

<https://learn.ibm.com/mod/video/view.php?id=167242>

<https://learn.ibm.com/mod/video/view.php?id=168614>

<https://learn.ibm.com/mod/page/view.php?id=170229&forceview=1>

2.3.2.2. Understand and implement pros, cons, and how to of up-, down-, and re-sampling

REFERENCES:

<https://learn.ibm.com/mod/video/view.php?id=167243>

<https://learn.ibm.com/mod/video/view.php?id=167247>

<https://learn.ibm.com/mod/video/view.php?id=167246>

<https://learn.ibm.com/mod/page/view.php?id=170230&forceview=1>

<https://learn.ibm.com/mod/video/view.php?id=168610&forceview=1>

2.3.2.3. Understand and implement other methods to handle imbalanced data, such as weighting and stratified sampling

REFERENCES:

<https://learn.ibm.com/mod/video/view.php?id=167245>

<https://imbalanced-learn.org/stable/index.html> (included in videos)

<https://learn.ibm.com/mod/page/view.php?id=170231>

Section 3 – Implement the proper model

3.1. Implement Supervised Learning: Regression

SUBTASK(S):

3.1.1. Describe Regression

REFERENCES:

<https://towardsdatascience.com/supervised-learning-basics-of-linear-regression-1cbab48d0eba>

3.1.2. Understand the benefits of Regression

REFERENCES:

<https://towardsdatascience.com/supervised-learning-the-what-when-why-good-and-bad-part-1-f90e6fe2a606>

3.1.3. Understand some of the most popular Regression algorithms

3.1.3.1. Gradient Boosting Tree

3.1.3.2. Neural Network

3.1.3.3. Random Forest

3.1.3.4. Linear Regression

3.1.3.5. Decision Tree

REFERENCES:

https://scikit-learn.org/stable/supervised_learning.html

3.2. Implement Supervised Learning: Classification**SUBTASK(S):**

3.2.1. Describe Classification

REFERENCES:

<https://towardsdatascience.com/supervised-learning-the-what-when-why-good-and-bad-part-1-f90e6fe2a606>

3.2.2. Understand the benefits of Classification

REFERENCES:

<https://www.javatpoint.com/regression-vs-classification-in-machine-learning>

3.2.3. Understand some of the most popular Classification algorithms

3.2.3.1. Naïve Bayes

3.2.3.2. Linear SVM

3.2.3.3. Logistic Regression

3.2.3.4. K-Nearest Neighbors

3.2.3.5. Stochastic Gradient Descent

3.2.3.6. Neural Network

3.2.3.7. Decision Trees & Random Forest

3.2.3.8. Boosting Classifiers

REFERENCES:

<https://analyticsindiamag.com/7-types-classification-algorithms/>

3.3. Implement Unsupervised Learning: Clustering**SUBTASK(S):**

3.3.1. Describe Clustering

REFERENCES:

<https://machinelearningmastery.com/clustering-algorithms-with-python/>

3.3.2. Understand the benefits of Clustering

REFERENCES:

<https://www.explorium.ai/blog/clustering-when-you-should-use-it-and-avoid-it/>

3.3.3. Understand some of the most popular Clustering algorithms

3.3.3.1. K-means

3.3.3.2. Gaussian Mixture Model

3.3.3.3. DBSCAN

REFERENCES:

<https://scikit-learn.org/stable/modules/clustering.html>

Additional REFERENCES:

<https://www.statlearning.com/>

<http://www.mmds.org/>

<https://scikit-learn.org/stable/modules/mixture.html#gmm>

<https://www.aaai.org/Papers/KDD/1996/KDD96-037.pdf>

<https://www.dbs.ifi.lmu.de/Publikationen/Papers/OPTICS.pdf>

3.4. Implement Unsupervised Learning: Dimensional Reduction**SUBTASK(S):**

3.4.1. Describe Dimensional Reduction

REFERENCES:

<https://machinelearningmastery.com/dimensionality-reduction-for-machine-learning/>

3.4.2. Understand the benefits of Dimensional Reduction

REFERENCES:

<https://machinelearningmastery.com/dimensionality-reduction-for-machine-learning/>

3.4.3. Understand some of the most popular Dimensional Reduction Algorithms

3.4.3.1. Singular Value Decomposition

3.4.3.2. Latent Dirichlet Analysis

3.4.3.3. Principal Component Analysis

REFERENCES:

<https://machinelearningmastery.com/dimensionality-reduction-algorithms-with-python/>

General Reference for differentiation:

<https://www.ibm.com/cloud/blog/supervised-vs-unsupervised-learning>

Additional References

<https://www.statlearning.com/>

<http://www.mmds.org/>

<https://geometria.math.bme.hu/sites/geometria.math.bme.hu/files/users/csgeza/howard-anton-chris-rorres-elementary-linear-algebra-applications-version-11th-edition.pdf>

<https://jmlr.org/papers/volume18/14-546/14-546.pdf>

https://en.wikipedia.org/wiki/Curse_of_dimensionality

Section 4 - Refine and deploy the model

4.1. Identify operations and transformations taken to select and engineer features

SUBTASK(S):

4.1.1. Obtain raw data

4.1.2. Engineer features using attributes of the raw data

4.1.3. Use automated techniques to augment and/or select features for use in learning

REFERENCES:

<https://machinelearningmastery.com/discover-feature-engineering-how-to-engineer-features-and-how-to-get-good-at-it/>

<https://developer.ibm.com/articles/automated-feature-engineering-for-relational-data-with-ibm-autoai/>

<https://developer.ibm.com/patterns/model-mgmt-on-watson-studio-local/>

4.2. Select the proper tools

SUBTASK(S):

4.2.1. Identify the tools required based on the:

4.2.1.1. Model type

4.2.1.2. Type of data

4.2.1.3. Feature engineering requirements

4.2.1.4. Amount of automation desired

4.2.1.5. Production environment requirements

REFERENCES:

<https://www.ibm.com/garage/method/practices/reason/evaluate-and-select-machine-learning-algorithm/>
<https://developer.ibm.com/articles/cc-models-machine-learning/>
https://www.ibm.com/support/producthub/icpdata/docs/content/SSQNUZ_latest/wsj/analyze-data/ml-overview_local.html
https://www.ibm.com/support/producthub/icpdata/docs/content/SSQNUZ_latest/wsj/getting-started/tools.html

4.3. Configure the appropriate environment specifications for training the model

SUBTASK(S):

- 4.3.1. Identify the frameworks supported by Watson Machine Learning
- 4.3.2. Explain the GPU-accelerated computing

REFERENCES:

<https://dataplatform.cloud.ibm.com/docs/content/wsj/analyze-data/ml-overview.html>
https://dataplatform.cloud.ibm.com/docs/content/wsj/analyze-data/pm_service_supported_frameworks.html

4.4. Train the model and optimize hyperparameters

SUBTASK(S):

- 4.4.1. Choose and justify the type of algorithm
 - 4.4.1.1. Regression
 - 4.4.1.2. Classification
 - 4.4.1.3. Clustering
 - 4.4.1.4. Recommendation engines
 - 4.4.1.5. Anomaly detection
- 4.4.2. Describe the trade-offs between underfitting and overfitting a model
 - 4.4.2.1. Avoid underfitting or overfitting by splitting the data into training, testing, and validation sets
- 4.4.3. Compare model parameters and hyperparameters
- 4.4.4. Explain hyperparameters and hyperparameter tuning
 - 4.4.4.1. Tuning is a trial-and-error process
 - 4.4.4.2. Tuning is based on the training output loss value
 - 4.4.4.3. Learning rate, number of epochs, hidden layers, hidden units, activation functions
- 4.4.5. Summarize search algorithms
 - 4.4.5.1. Grid Search
 - 4.4.5.2. Random Search
 - 4.4.5.3. Bayesian Optimization
- 4.4.6. Ensemble multiple models
- 4.4.7. Choose and justify the type of algorithm
 - 4.4.7.1. Regression
 - 4.4.7.2. Classification
 - 4.4.7.3. Clustering
 - 4.4.7.4. Recommendation engines

4.4.7.5. Anomaly detection

REFERENCES:

<https://www.ibm.com/garage/method/practices/reason/optimize-train-ai-model/>
<https://www.ibm.com/docs/en/wmla/2.2.0?topic=optimization-hyperparameter-search-algorithms>
<https://www.ibm.com/garage/method/practices/reason/evaluate-and-select-machine-learning-algorithm/>
<https://developer.ibm.com/articles/cc-models-machine-learning/>
<https://www.ibm.com/garage/method/practices/reason/evaluate-and-select-machine-learning-algorithm/>
<https://developer.ibm.com/articles/cc-models-machine-learning/>

4.5. Implement the ability for the model to explain itself

SUBTASK(S):

- 4.5.1. Determine what user profiles need explanations
- 4.5.2. Determine what sort of explanations will make sense to those users
- 4.5.3. Select and apply algorithms to generate model explanations
 - 4.5.3.1. Boolean Decision Rule
 - 4.5.3.2. Generalized Linear Rule Model
 - 4.5.3.3. ProfWeight
 - 4.5.3.4. Teaching Explanations for Decisions (TED)
 - 4.5.3.5. Contrastive Explanations
 - 4.5.3.6. Disentangled Inferred Prior VAE
 - 4.5.3.7. ProtoDash
- 4.5.4. Present explanations in a form that will make sense to the target users

REFERENCES:

<https://learn.ibm.com/course/view.php?id=8717>
<https://learn.ibm.com/course/view.php?id=8718>
<https://aix360.mybluemix.net/>

4.6. Deploy the model

SUBTASK(S):

- 4.6.1. Containerize the model with Docker
- 4.6.2. Embed the model into Spark
- 4.6.3. Deploy the model with Watson Machine Learning

REFERENCES:

<https://learn.ibm.com/course/view.php?id=8797>

Section 5 - Monitor models in production

5.1. Assess the model

SUBTASK(S):

- 5.1.1. Distinguish metrics for Classification Models
 - 5.1.1.1. Explain how a confusion matrix works
 - 5.1.1.2. Explain what AUC measures
 - 5.1.1.3. ROC curve

Reference for plots with ROC curves:

<https://people.inf.elte.hu/kiss/11dwhdm/roc.pdf>

<https://synapse.koreamed.org/articles/1027596>

- 5.1.1.4. Difference in distance measurements
 - 5.1.1.4.1. Manhattan
 - 5.1.1.4.2. Euclidean
 - 5.1.1.4.3. Cosine similarity

REFERENCES:

<https://learning.oreilly.com/library/view/thoughtful-machine-learning/9781491924129/>

Chapter 3, Distances

<https://towardsdatascience.com/9-distance-measures-in-data-science-918109d069fa>

- 5.1.1.5. Understand how tree-based models determine features to split on
- 5.1.2. Distinguish metrics for Regression Models
 - 5.1.2.1. How do L1 and L2 Regularization impact the model features
 - 5.1.2.2. Understand distinction between Bias and Variance
 - 5.1.2.3. What do MSE and R-Squared measure
 - 5.1.2.4. Understand common error metrics to evaluate regression models
- 5.1.3. Distinguish metrics for Unsupervised Models
 - 5.1.3.1. How do you determine optimal number of K for K-Means Algorithm
 - 5.1.3.2. Explain how the inertia metric is calculated
 - 5.1.3.3. Explain how the Distortion metric is calculated
 - 5.1.3.4. How can you avoid your centroids getting stuck in bad local optima
- 5.1.4. Identify trade-offs between model performance and computational cost
- 5.1.5. Choose the best metric for the model and business problem

REFERENCES:

https://scikit-learn.org/stable/modules/model_evaluation.html

<https://learn.ibm.com/mod/video/view.php?id=166640>

<https://learn.ibm.com/mod/page/view.php?id=170322&forceview=1>

<https://learn.ibm.com/mod/video/view.php?id=166668>

<https://learn.ibm.com/mod/video/view.php?id=166669>

<https://learn.ibm.com/mod/video/view.php?id=166785>
<https://learn.ibm.com/mod/page/view.php?id=170325&forceview=1>
<https://learn.ibm.com/mod/video/view.php?id=166786>
<https://learn.ibm.com/mod/page/view.php?id=170329&forceview=1>
<https://learn.ibm.com/mod/video/view.php?id=169061&forceview=1>

There is an error in learning material minute 5:10:

<https://learn.ibm.com/mod/video/view.php?id=166785> The presenter is talking about specificity and the formula for specificity is displayed, but it is incorrectly signed as “Sensitivity”. The next slide has corrected version of formula.

Supervised Machine Learning: Classification

Supervised Machine Learning: Classification / 1. Logistic Regression (Start Here) / Confusion Matrix, Accuracy, Specificity, Precision...

Confusion Matrix, Accuracy, Specificity, Precision, and Recall

C9_V04-Classification-Error-Metrics-Part-1

Specificity: Avoiding False Alarms

	Predicted Positive	Predicted Negative
Actual Positive	True Positive (TP)	False Negative (FN)
Actual Negative	False Positive (FP)	True Negative (TN)

$$\text{Sensitivity} = \frac{TN}{FP + TN}$$

That bottom row of actual negative classes

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5.2. Monitor the model in production

SUBTASK(S):

5.2.1. Understand what MLOps is

REFERENCES:

<https://www.ibm.com/blogs/journey-to-ai/2021/04/paving-the-paths-to-ai-engineering-and-modelops/>
<https://ibm-cloud-architecture.github.io/refarch-data-ai-analytics/methodology/MLOps/>
<https://learning.oreilly.com/library/view/introducing-mlops/9781492083283/ch01.html>

5.2.1.1. Understand types of data drift and their impact

5.2.2. Monitor model performance metrics using logging

<https://learn.ibm.com/mod/video/view.php?id=169287>
<https://learn.ibm.com/mod/page/view.php?id=169579&forceview=1>
<https://learn.ibm.com/mod/page/view.php?id=169581&forceview=1>
<https://learn.ibm.com/mod/page/view.php?id=169598&forceview=1>

5.2.3. Monitor model business KPIs

REFERENCES:

<https://learn.ibm.com/mod/page/view.php?id=170330&forceview=1>
<https://learn.ibm.com/mod/video/view.php?id=169575>

5.2.4. Decide when to retrain model

REFERENCES:

https://learning.oreilly.com/library/view/introducing-mlops/9781492083283/ch07.html#online_evaluation – Champion/Challenger section
https://learning.oreilly.com/library/view/ml-ops-operationalizing/9781492074663/ch01.html#retraining_and_remoting - Retraining and remodeling section
<https://learn.ibm.com/mod/video/view.php?id=169604>

5.2.5. Use IBM OpenPages to govern models

REFERENCES:

<https://www.ibm.com/docs/en/cloud-paks/cp-data/4.0?topic=governance-set-up-model-openpages-mrg>

5.3. Determine if there is unfair bias in the model

SUBTASK(S):

5.3.1. Understand how model bias can creep in

REFERENCES:

<https://www.brookings.edu/research/algorithmic-bias-detection-and-mitigation-best-practices-and-policies-to-reduce-consumer-harms/>
<https://developer.ibm.com/articles/machine-learning-and-bias/>

5.3.2. Understand the role of transparency in mitigating bias

REFERENCES:

<https://www.forbes.com/sites/cognitiveworld/2020/05/23/towards-a-more-transparent-ai/?sh=b928073d9371>

5.3.3. Create an AI FactSheet

REFERENCES:

<https://www.ibm.com/blogs/research/2020/07/aifactsheets/>

5.3.4. Detect bias in models using IBM AI Fairness 360 Toolkit and Watson OpenScale**REFERENCES:**

<https://developer.ibm.com/blogs/ai-fairness-360-raise-ai-right/>

<https://github.com/IBM/bias-mitigation-of-machine-learning-models-using-aif360/blob/main/README.md>

<https://learn.ibm.com/mod/video/view.php?id=168628>

<https://www.ibm.com/docs/en/cloud-paks/cp-data/4.0?topic=governance-manage-model-risk>

Next Steps

1. Take the [IBM Machine Learning Data Scientist v1](#) assessment test.
2. If you pass the assessment exam, visit pearsonvue.com/ibm to schedule your testing sessions.
3. If you failed the assessment exam, review how you did by section. Focus attention on the sections where you need improvement. Keep in mind that you can take the assessment exam as many times as you would like (\$30 per exam), however, you will still receive the same questions only in a different order.