

# Effects of Innovation Education and Corporate Needs -Analysis Using Bayesian Network

Tsuyoshi Aburai<sup>1</sup>, Kazuhiro Takeyasu<sup>2</sup>

<sup>1</sup> Tokushima University Research Center for Higher Education Division of Academic Learning Support Section of Innovation Education, Japan

<sup>2</sup> Research Institute for Management Information System, Japan

Correspondence: Tokushima University Research Center for Higher Education Division of Academic Learning Support Section of Innovation Education, 2-1 Minamijosanjimacho, Tokushima, Japan.

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## Abstract

This paper offers a clarification of the skills required for innovation talent by comparing the effect of innovation in education at Tokushima University and the talent requirement of companies. The researchers performed the questionnaire investigation with the use of the 19 items of The Innovator's DNA Skill Assessment. Both the basic statistical analysis and Bayesian Network analysis were conducted based on the resulting data. The sensitivity analysis was performed after building the Bayesian Network Model. The evidences are set to "skeptical thinking", "taking risks", and "creativity" in the item of mind. The calculation of the odds ratio reveals that enhancing the Observation skill and Skill to Plan and Design is effective in improving skeptical thinking and creativity.

**Keywords:** innovation education, design thinking, academic industrial collaboration, Bayesian network

## 1. Introduction

The ideal business setting is to sell products that are produced based on consumers' needs. However, in many cases, products are produced based on the resources available to companies. Businesses may find this challenging as user's preferences tend to change over time, making it difficult to make a product that fits well in the market. Another reason for this is that market is matured by the mass production and one to one marketing is required to conquer that (Takeyasu, K., et al., 2013). Our university barely presents a systematic instruction to search for users' needs, and this is despite the transition from seeds orientation to needs orientation of most businesses.

The extracurricular activities "Innovation challenge club" under Academic Industrial Collaboration (AIC) for undergraduate has launched since April 2018 in Tokushima University. It aims to solve the job and talent mismatch issues faced by companies located in Tokyo and Osaka. As far as this theme concerned, it is a unique approach made by Tokushima University and cannot be found in other universities. They intended to make final presentation on October 2018. Table 1 shows the themes of the collaborating companies. The companies' participating staffs belong to business departments and research development departments. Further, design thinking was tested on the graduate students of technical management advanced course at university during April to July 2018. Application of this design thinking method to the existing problem under the collaboration with university and companies may be the first one as we cannot find any former researches.

In this paper, the author offers an examination of the skills needed for innovation talent by comparing the innovation education taught at Tokushima University and the skills most companies require.

Table 1. Themes of the companies

Company name	Theme
JTEKT Corporation	Commodity for consumers and business model utilizing bearing (JTEKT Corporation is a big manufacturer which produces bearings.)
Panasonic Cycle Technology Co., Ltd.	Electro motion bicycle which changes Tokushima district's traffic infrastructure
YANMAR Co., Ltd	Autonomous robot shade from bird YANMAR Co. owns three exercise practice fields for football team. Ducks take rest in winter there and eat the lawn roots and defecate. Therefore robots which drive off ducks are developed.
YKK CORPORATION	Development of application of self-propelling fastener Fastener with small motor run automatically by the remote control of smart phone.

## 2. Solve the Companies' Issue by the Design Thinking

In design thinking, sympathizing with the consumers, such as knowing their inconveniences, is the first step to develop new products or services. The user's feedback on their experience about the prototype of the product is critical during the development stage. A better product is created by repeating the improvement based upon the user's feedback. In this instance, a simple version is presented for the product prototype. This strategy is favorable as it allows for efficient and timely product development according to customer specifications.

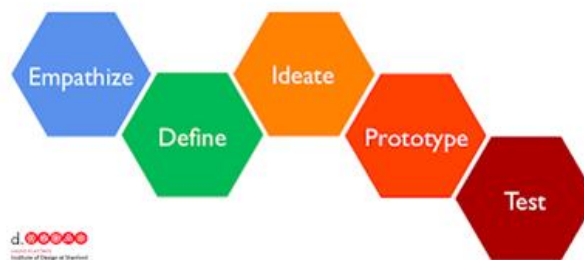


Figure 1. Process of design thinking ([http://beyondthenexus.com/designthinking\\_empathy\\_innovation/](http://beyondthenexus.com/designthinking_empathy_innovation/))

## 3. Outline of the Questionnaire Investigation

The researchers performed the questionnaire investigation with the use of the 19 items of The Innovator's DNA Skill Assessment. The resulting data served as a basis in conducting both basic statistical analysis and Bayesian Network analysis.

Innovator's DNA Skill Assessment is a diagnostic tool developed by Clayton Professor of Harvard Business School. It is comprised of 19 items that are classified in 4 divisions, namely Skill, Mind, Skill to execute, Skill of inducing others the innovation as shown in Table 2.

Table 2. The Innovator’s DNA Skill Assessment 19 items (The Innovator’s DNA <https://innovatorsdna.com/>)

Skill	Skill to associate
	Skill to inquire
	Observation skill
	Skill to make experiment
	Networking skill
Mind	Skeptical thinking
	Taking risks
	Creativity
Skill to execute	Skill to analyze
	Skill to plan and design
	Introducing skill
	Skill to execute
Skill of inducing others the innovation	Skill to induce the others to associate
	Skill to induce the question of the other members
	Skill to induce other members to observe
	Skill to induce other members to make experiment
	Skill to induce other members to have networking skill
	Skill to induce other members to challenge the current status
	Skill to induce other members to take risk

The outline of the questionnaire investigation is as follows

- 1) Scope of investigation: Students who took innovation education, Collaborated companies
- 2) Date: July 17~September 19 2018
- 3) Method: Self writing to the questionnaire sheet
- 4) Collection: Number of distribution 50, Number of collection 41 (Collection rate 82%), Valid answer 41

**4. Basic Statistical Results**

Now, we show the main summary results by single variable.

*4.1 Sex*

Male 34, Female 4

These are exhibited in Figure 2.

83% are the male.

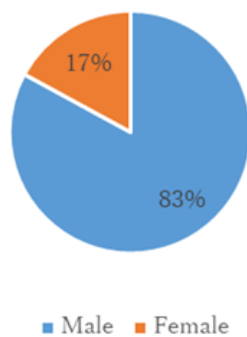


Figure 2. Sex

*4.2 Affiliation*

Undergraduate 21, Graduated students 15

Company members 5 (JTEKT Corporation 1, Panasonic Cycle Technology Co., Ltd. 1, YANMAR Co., Ltd 2, YKK CORPORATION 1) (Figure 3).

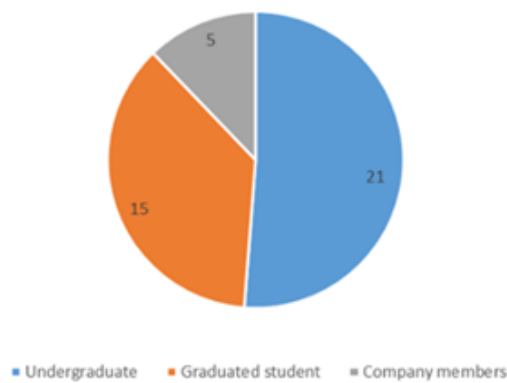


Figure 3. Affiliation

### 4.3 Innovation Index

Students have selected the rank of item which is classified into 5 (stage 1~stage 5) where their skill have advanced. As for the company employee, they have selected the rank of item which is classified into 5 (stage 1~stage 5) which is required as the innovation talent.

#### 4.3.1 Undergraduate

From Figure 4, we observe that most of the item in the most advanced skill is Net-working skill (Skill) and then Skill to associate (Skill), Skeptical thinking (Mind) and Skill to inquire (Skill) follow.

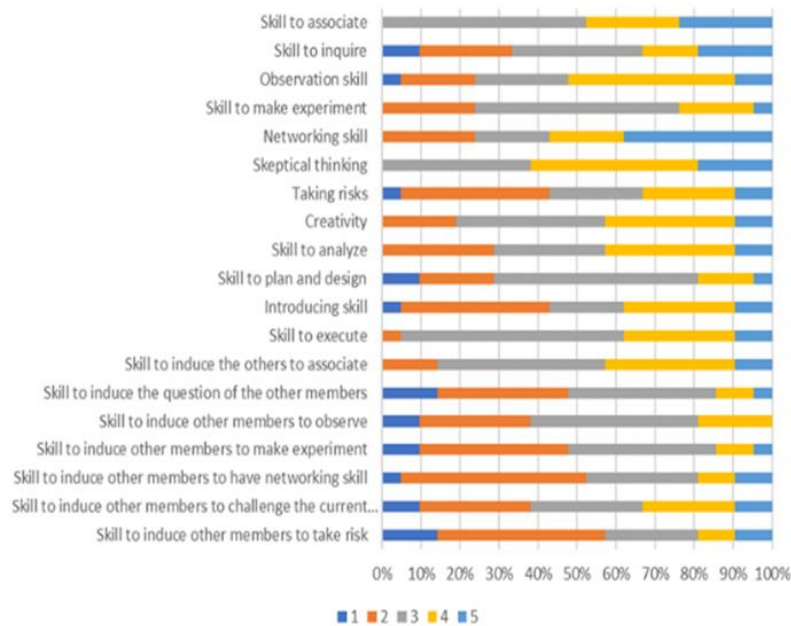


Figure 4. Undergraduate

#### 4.3.2 Graduated Students

From Figure 5, we observe that most of the item in the most advanced skill is Networking skill (Skill) and then Creativity (Mind), Skill to plan and design (Skill to execute), Observation skill (Skill) follow.

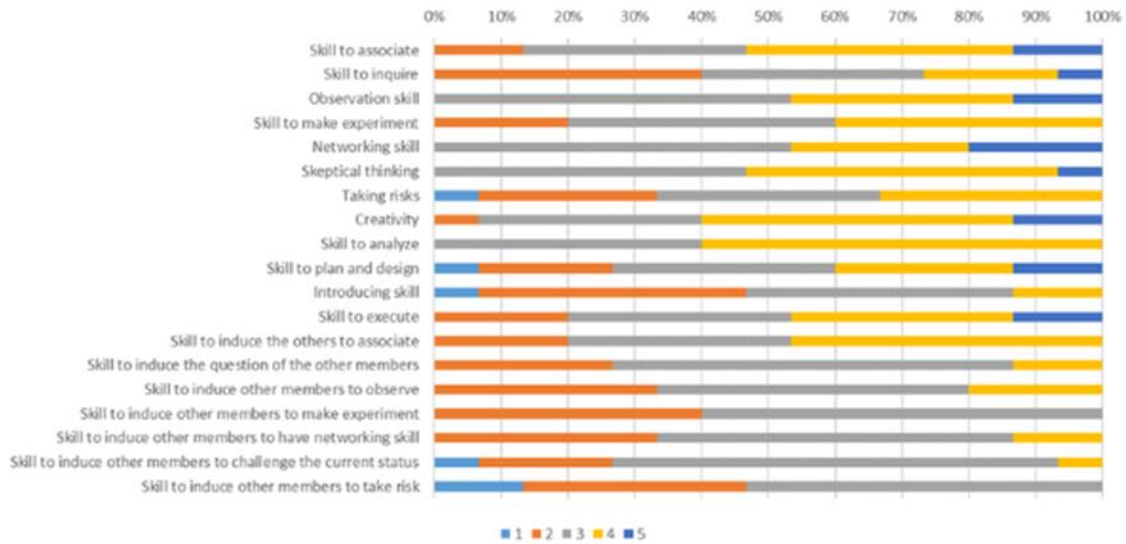


Figure 5. Graduated students

#### 4.3.3 Company Employee

From Figure 6, we observe that most of the three items in the most advanced skill is Skeptical thinking (Mind), Skill to inquire (Skill) and Skill to plan and design (Skill to execute).



Figure 6. Company employee

### 5. Bayesian Network Analysis

In recent years, Bayesian Network is highlighted because it has the following good characteristics (Neapolitan, R.E., 2004).

- Structural Equation Modeling requires normal distribution to the data in the analysis. Therefore it has a limitation in making analysis. But Bayesian Network does not require specific distribution type to the data. It can handle any distribution type.
- It can handle the data which include partial data.
- Expert’s know-how can be reflected in building Bayesian Network model.
- Sensitivity analysis can be easily executed by settling evidence. We can estimate and predict the prospective purchaser by that analysis.

●It is a probability model having network structure. Related items are connected with directional link. Therefore understanding becomes easy by its visual chart.

In this research, it is suitable to utilize Bayesian Network to analyze this questionnaire investigation.

The construction of the Bayesian Network model requires checking the causal relationship among groups of items. It is because the Bayesian Network is constructed by the link of items and there should be causal relationship when making links. We used BAYONET software found at <http://www.msi.co.jp/BAYONET/> for this purpose. The existence of plural nodes in the same group results in the difficult of determining a causal relationship. The BAYONET system is useful in this case as it utilizes the AIC standard to set the sequence automatically.

The implication of the research outcome in relation to innovation education relates with the importance of building the model and utilizing the AIC standard.

Based on this, a model is built as is shown in Figure 7.



Figure 7. Built model

### 6. Sensitivity Analysis

Sensitivity analysis is executed based on the evidence gathered for each item. We select the “Mind” where the companies require. This resonates with the requirements of most companies, wherein the mind category comprised of "Skeptical thinking”, “Taking risks” and “Creativity”. The change of innovation index is captured by comparing the Prior probability and Posterior probability. Appendix 3 shows the calculation results of Posterior probability after setting evidence to each item. Odds ratio is calculated in order to make change rate clear (Table 3).

Table 3. Prior probability, Posterior probability and odds ratio

		Prior probability	Mind		
			Skeptical thinking Odds ratio	Taking risks Odds ratio	Creativity Odds ratio
Skill	Skill to associate	0.496	1.002	1.001	1.002
	Skill to inquire	0.370	1.002	1.002	1.002
	Observation skill	0.514	1.002	1.002	1.003
	Skill to make experiment	0.318	1.000	1.002	1.002
	Networking skill	0.518	1.002	1.000	1.002
Skill to execute and promote	Skill to analyze	0.496	1.001	1.002	1.002
	Skill to plan and design	0.348	1.003	1.002	1.003
	Introducing skill	0.265	0.999	0.999	1.000
	Skill to execute	0.451	1.002	1.002	1.002

The result of this analysis reveals that enhancing the [Skill to plan and design] (Skill to execute) is effective for improving Skeptical thinking ability with respect to odds ratio equal to 1.003 in Table 3. Furthermore, it also shows that enhancing the Observation skill (Skill) and Skill to plan and design (Skill to execute) is effective for improving creativity.

## 7. Conclusion

Tokushima University has since integrated innovation education in its system. A questionnaire investigation is executed to examine the skills required for the innovation talent by comparing the effect of innovation education at Tokushima University with the company requirements.

Based upon these data, basic statistical analysis and Bayesian Network analysis are conducted. Bayesian Network model is built and the sensitivity analysis is performed.

The result of this study reveals that enhancing the Observation skill and Skill to plan and design is effective for strengthening Skeptical thinking and Creativity.

These results would properly be implicated in the companies' business administration.

Based upon these analyses, innovation education in our university should be revised so as to meet the companies' requirement of talent as was made clear.

Although it has a limitation that it is restricted in the number of questionnaire investigation, further consecutive research will make it more adequate and bear better results.

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<http://www.msi.co.jp/bayonet/cases.html>

<https://innovatorsdna.com/>

**Appendix A**

Questionnaire Investigation

Self-Evaluation Check Sheet (Undergraduate, Graduated students) 2018

Faculty ( ) Department ( ) Grade ( )

Name ( )

Select rank of item which fit most to you and set five ○ at which your skill has advanced.

Your skill has advanced (Set 5 ○)	Items					
	Skill to associate	1	2	3	4	5
	Skill to combine plural elements or ideas					
	Skill to inquire	1	2	3	4	5
	Skill to grasp users' insight and/or essence not to do it by the hypothesis verification					
	Observation skill	1	2	3	4	5
	Skill to observe the fact thoroughly					
	Skill to make experiment	1	2	3	4	5
	Experiment skill to evaluate users as well as thinking					
	Networking skill	1	2	3	4	5
	Skill to utilize the others wisdom					
	Skeptical thinking	1	2	3	4	5
	Skill to demonstrate about current condition					
	Taking risks	1	2	3	4	5
	Skill to take risk resolutely					
	Creativity	1	2	3	4	5
	Confidence to bear creative idea					
	Skill to analyze	1	2	3	4	5
	Skill to analyze, combine, and check from other points					
	Skill to plan and design	1	2	3	4	5
	Skill to plan, design and promote for the further step					
	Introducing skill	1	2	3	4	5
	Skill to introduce innovation tool to the team member					
	Skill to execute	1	2	3	4	5
	Skill to execute with discipline in order to perform systematically					
	Skill to induce the others to associate	1	2	3	4	5
	Skill to induce the other members to have the power of combining the plural elements and ideas					
	Skill to induce the question of the other members	1	2	3	4	5
	Skill to induce other members to grasp users' insight and/or essence not to do it by the hypothesis verification					
	Skill to induce other members to observe	1	2	3	4	5
	Skill to induce other members to observe the fact thoroughly					
	Skill to induce other members to make experiment	1	2	3	4	5
	Skill to induce other members to have experiment skill to evaluate users as well as thinking					
	Skill to induce other members to have networking skill	1	2	3	4	5
	Skill to induce other members to utilize the others wisdom					
	Skill to induce other members to challenge the current status	1	2	3	4	5
	Skill to induce other members to remonstrate about current condition					
	Skill to induce other members to take risk	1	2	3	4	5
	Skill to induce other members to take risk resolutely					



Guideline for the evaluation of 1~5

1. There is no experience
2. Have little bit experience but cannot have confidence
3. Have confidence to some extent
4. Maybe superior compared with others
5. Have enough experience

**Appendix B**

Questionnaire Investigation

Innovation talent (Company employee) 2018

Company name ( ) Name ( )

Select rank of item which is required as the innovation talent and set five ○ in which innovation talent is re-quired.

Your skill has advanced (Set 5 ○)	Items					
	Skill to associate	1	2	3	4	5
	Skill to combine plural elements or ideas					
	Skill to inquire	1	2	3	4	5
	Skill to grasp users' insight and/or essence not to do it by the hypothesis verification					
	Observation skill	1	2	3	4	5
	Skill to observe the fact thoroughly					
	Skill to make experiment	1	2	3	4	5
	Experiment skill to evaluate users as well as thinking					
	Networking skill	1	2	3	4	5
	Skill to utilize the others wisdom					
	Skeptical thinking	1	2	3	4	5
	Skill to remonstrate about current condition					
	Taking risks	1	2	3	4	5
	Skill to take risk resolutely					
	Creativity	1	2	3	4	5
	Confidence to bear creative idea					
	Skill to analyze	1	2	3	4	5
	Skill to analyze, combine, and check from other points					
	Skill to plan and design	1	2	3	4	5
	Skill to plan, design and promote for the further step					
	Introducing skill	1	2	3	4	5
	Skill to introduce innovation tool to the team member					
	Skill to execute	1	2	3	4	5
	Skill to execute with discipline in order to perform systematically					

	Skill to induce the others the associate	1	2	3	4	5
	Skill to induce the other members to have the power of combining the plural elements and ideas					
	Skill to induce the question of the other members	1	2	3	4	5
	Skill to induce other members to grasp users' insight and/or essence not to do it by the hypothesis verification					
	Skill to induce other members to observe	1	2	3	4	5
	Skill to induce other members to observe the fact thoroughly					
	Skill to induce other members to make experiment	1	2	3	4	5
	Skill to induce other members to have experiment skill to evaluate users as well as thinking					
	Skill to induce other members to have networking skill	1	2	3	4	5
	Skill to induce other members to utilize the others wisdom					
	Skill to induce other members to challenge the current status	1	2	3	4	5
	Skill to induce other members to remonstrate about current condition					
	Skill to induce other members to take risk	1	2	3	4	5
	Skill to induce other members to take risk resolutely					

Guideline for the evaluation of 1~5

1. There is no need
2. Have little bit need
3. Better to have it
4. Required to some extent
5. Essential

### Appendix C

Prior probability, Posterior probability and odds ratio

		Prior probability	Affiliation			
			Company Posterior probability	Company Odds ratio	Un dergraduate Posterior probability	Undergraduate Odds ratio
Affiliation	Company	0.136	1	-	0	0.000
	Undergraduate	0.500	0	0	1	-
	Graduated students	0.364	0	0	0	0.000
Skill	Skill to associate	0.496	0.625	1.692	0.458	0.859
	Skill to inquire	0.370	0.750	5.109	0.333	0.852
	Observation skill	0.514	0.750	2.838	0.500	0.946
	Skill to make experiment	0.318	0.375	1.289	0.250	0.716
	Networking skill	0.518	0.625	1.553	0.542	1.101
Mind	Skeptical thinking	0.501	0.506	1.021	0.501	0.999
	Taking risks	0.334	0.338	1.021	0.333	0.999
	Creativity	0.334	0.338	1.018	0.334	0.999
Skill to execute and promote	Skill to analyze	0.496	0.625	1.696	0.417	0.727
	Skill to plan and design	0.348	0.750	5.624	0.208	0.493
	Introducing skill	0.265	0.125	0.396	0.375	1.663
	Skill to execute	0.451	0.750	3.646	0.375	0.729

Affiliation		Skill			
Graduated students Posterior probability	Graduated students Odds ratio	Skill to associate Posterior probability	Skill to associate Odds ratio	Skill to inquire Posterior probability	Skill to inquire Odds ratio
0	0.000	0.172	1.313	0.276	2.420
0	0.000	0.462	0.858	0.451	0.820
1	-	0.366	1.012	0.273	0.657
0.500	1.015	1	-	0.516	1.081
0.278	0.655	0.385	1.064	1	-
0.444	0.757	0.523	1.035	0.554	1.175
0.389	1.368	0.322	1.022	0.322	1.023
0.444	0.745	0.520	1.011	0.538	1.086
0.501	1.000	0.501	1.003	0.502	1.004
0.334	1.000	0.334	1.001	0.334	1.003
0.334	1.000	0.334	1.001	0.334	1.003
0.556	1.272	0.503	1.032	0.512	1.069
0.389	1.193	0.368	1.089	0.407	1.289
0.167	0.554	0.256	0.952	0.249	0.919
0.444	0.972	0.465	1.056	0.498	1.204

Skill					
Observation skill Posterior probability	Observation skill Odds ratio	Skill to make experiment Posterior probability	Skill to make experiment Odds ratio	Networking skill Posterior probability	Networking skill Odds ratio
0.199	1.574	0.161	1.216	0.165	1.248
0.486	0.947	0.394	0.649	0.523	1.097
0.314	0.803	0.445	1.405	0.312	0.794
0.505	1.034	0.504	1.031	0.499	1.010
0.399	1.130	0.376	1.025	0.385	1.064
1	-	0.516	1.007	0.524	1.041
0.319	1.005	1	-	0.314	0.983
0.528	1.041	0.512	0.977	1	-
0.501	1.003	0.501	1.000	0.501	1.002
0.334	1.001	0.334	1.002	0.333	1.000
0.334	1.003	0.334	1.002	0.334	1.002
0.502	1.025	0.512	1.068	0.494	0.995
0.373	1.115	0.376	1.130	0.354	1.027
0.260	0.972	0.242	0.885	0.269	1.019
0.471	1.084	0.466	1.062	0.458	1.029

Mind					
Skeptical thinking Posterior probability	Skeptical thinking Odds ratio	Taking risks Posterior probability	Taking risks Odds ratio	Creativity Posterior probability	Creativity Odds ratio
0.137	1.003	0.137	1.003	0.137	1.004
0.500	0.999	0.500	0.998	0.500	0.998
0.364	1.000	0.364	1.000	0.364	1.000
0.497	1.002	0.497	1.001	0.497	1.002
0.370	1.002	0.370	1.002	0.370	1.002
0.514	1.002	0.514	1.002	0.515	1.003
0.318	1.000	0.318	1.002	0.318	1.002
0.518	1.002	0.518	1.000	0.518	1.002
1	-	0.501	1.000	0.501	1.000
0.334	1.000	1	-	0.334	1.000
0.334	1.000	0.334	1.000	1	-
0.496	1.001	0.496	1.002	0.496	1.002
0.348	1.003	0.348	1.002	0.348	1.003
0.265	0.999	0.265	0.999	0.265	1.000
0.452	1.002	0.452	1.002	0.452	1.002

Skill to execute and promote							
Skill to analyze Posterior probability	Skill to analyze Odds ratio	Skill to plan and design Posterior probability	Skill to plan and design Odds ratio	Introducing skill Posterior probability	Introducing skill Odds ratio	Skill to execute Posterior probability	Skill to execute Odds ratio
0.172	1.315	0.294	2.638	0.064	0.435	0.227	1.855
0.420	0.725	0.299	0.427	0.707	2.415	0.415	0.711
0.408	1.204	0.407	1.199	0.229	0.519	0.358	0.976
0.504	1.032	0.524	1.119	0.479	0.932	0.511	1.061
0.382	1.054	0.433	1.302	0.347	0.907	0.408	1.173
0.520	1.026	0.551	1.160	0.503	0.959	0.537	1.096
0.328	1.050	0.343	1.123	0.290	0.877	0.328	1.049
0.516	0.995	0.527	1.037	0.525	1.029	0.526	1.033
0.501	1.001	0.502	1.005	0.501	0.999	0.501	1.003
0.334	1.002	0.334	1.004	0.333	0.999	0.334	1.002
0.334	1.001	0.335	1.003	0.334	1.000	0.334	1.002
1	-	0.534	1.168	0.462	0.873	0.514	1.075
0.375	1.125	1	-	0.284	0.745	0.396	1.228
0.247	0.909	0.217	0.767	1	-	0.244	0.893
0.468	1.068	0.513	1.283	0.415	0.862	1	-

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