



Theory of Belief Functions to Cognitive Learning Styles Diagnostic

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Abstract: This paper presents cognitive learning styles diagnostic using theory of belief functions. We have categorised learners into three types which include physically oriented, emotionally oriented, and mentally oriented. A scale of measurement in ordinal scale has been used to determine an individual's cognitive learning style levels. By using the scale of measurement in ordinal scale, it helps us develop a numerical hypothesis that is then used to determine an individual's cognitive learning style using the theory of belief functions or mathematical theory of evidence. Using thirty sixth set of questions, the paper used the evidence presented to support a given learning of a specific individual and filtered it using various degrees of probabilities of the evidence theory model which have aided in proving or validating a particular hypothesis. The conclusion made is that we can be able to easily diagnose an individual's cognitive learning styles using the theory of belief functions.

Keywords: education, learner, learning style, cognitive learning style, theory of belief functions

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1. Introduction

Cognitive learning styles comprise of the information processing styles that an individual possesses [1]. It differs slightly from one's ability as cognition provides a description of the typical mode of thinking of an individual, perception, remembrance and problem solving capabilities of an individual [2]. An inclusive description of cognitive learning styles focuses on a personality dimension that influences values, attitude as well as the social interaction of an individual [3]. For example, it entails how an individual is capable of processing and experiences and knowledge. Likewise, how a person organizes and retains information is also an important facet of the cognitive learning styles [4]. In most instances, cognitive learning styles determine the visualization of a task before one starts doing it [5]. Furthermore, it also influences the learning and teaching approach, whether sequentially or randomly. Therefore, it is important to analyze these styles to facilitate an understanding of the various psychological and physical behaviors of an individual [6]. Notably, there are three key cognitive learning styles, which include: physically oriented, emotionally oriented and mentally oriented cognitive learning styles [7]. In this research, we described how theory of belief functions can be used for dealing with cognitive learning styles. The rest of the paper is organized as follows. The next section describes cognitive learning styles: physical, emotional and mental. Section 3 explains theory of belief functions. Section 4 explains implementation of theory of belief functions to cognitive learning style diagnostic. Section 5 describes results and discussion. Finally, conclusions are included in the last section.

2. Cognitive Learning Style: Physical, Emotional, and Mental

According to El-Bishouty et al [8] physical cognition as a style of learning has been one of the significant

mode of acquiring knowledge among both human and other creatures. Furthermore, Shettleworth [9] adds that individuals have developed the ability to solve means-end tasks as well as other unraveled considerable variation in strategies through an application of physically oriented mechanisms. Humans have been at the leading edge of solving an on-off condition using a physical means. The process of physical cognition style of learning entails dependent and independent specific procedures or techniques of carrying out a particular problem solving task [9]. Eisenberg [10] identifies emotional oriented cognition as one of the significant learning styles that is common among students with high IQs. These students always develop the capability of doing new ideas and theories with ease and do not rely on any other means, including the help of their instructor, to get them started [10]. Hence, the students are able to read through the instructions provided for the completion of a specific and proceed to handle the tasks on their own. However, just like in physical oriented learning, Eisenberg notes that learners with emotional cognition also rely on real life situations to conceptualize new ideas and theories. Nevertheless, they relate these ideas and theories with the real life situations more easily than students with physical cognition style of learning who have to undertake repetitive procedures to ensure that they are correct [11].

Mental cognition is referred to as a special type of learning style as the learner prefers learning on his or her own with minimal intervention of an instructor [12]. The style of learning is mostly common in online or virtual and distance learning. Under such instances, the learner dedicates his or her time to reading and carrying out personal assessments without minimal guidance. The learner only attends specialist lectures or sessions to supplement the already acquired knowledge. During the specialist sessions, the learner seeks clarification. In most instances, learners under this category prefer a one-on-one session rather than the combined several students with one instructor [13]. However, some learners may not even require instructional involvement of the instructor. They can read on their own, follow course outline and prepare for exams adequately.

Mental cognitive style of learning is not a common style and only a few learners are capable of managing such kind of learning [12]. Besides, it is only possible in certain disciplines that entails theoretical content and limited practical content. For instance, a learner might not be able to carry out mathematical calculations on his or her own from scratch. Therefore, learners in such disciplines require instructions and guidance before they master the procedural ways of completing subsequent tasks. Over time, this kind of learning has been used frequently by adults who are pursuing their postgraduate studies since they have the primary knowledge, which is important in acquiring additional knowledge [12]. Noteworthy, these learners often set their schedules and in case they have to attend a one-on-one teaching session, then the lecturer needs to adhere to their schedules. Often, they engage in lectures in the evenings and during weekends. Table 1 shows cognitive learning style question sets [14]. The question sets ask the user to answer a number of questions in order to assess their learning style.

Table 1. Cognitive learning style question sets

No.	Cognitive Learning Style: Physical, Emotional, Mental Dimensions Question Sets	Physical/Mental/Emotional
1	Do you like to work on your own and take your time in your learning?	Mental {M}
2	Do you attend specialist lectures or sessions to supplement your learning?	Mental {M}
3	If you were given the opportunity, would you prefer one-on-one teaching sessions?	Mental {M}
4	Do you learn best through practical examples and demonstrations?	Physical {P}
5	Do you learn best when there is explanatory information provided to support your learning?	Physical {P}
6	Do you learn best without prescriptive written instructions?	Emotional {E}
7	If you were given the choice, would you prefer to follow your own learning routine along your own schedule?	Mental {M}
8	Do you prefer to follow clear guidelines when you are learning something new?	Physical {P}
9	Do you prefer to develop your own routine without time restrictions when you learn?	Mental {M}
10	Do you generally produce concise and useful information when you write?	Mental {M}
11	When you write, do you generally produce many drafts before arriving at the final version?	Physical {P}

12	Do you like to express your own opinions when you write?	Physical {P}
13	When you are learning something new, do you like to relate the new topic to something you already know?	Physical {P}
14	When you are learning something new, do you usually begin by forming a visual image of the topic?	Mental {M}
15	When you are learning something new, do you like to begin by gathering as much information as possible?	Mental {M}
16	Do you feel that beginning a new topic is a relatively easy process?	Emotional {E}
17	Do you usually focus on the practical details of what you have learnt?	Physical {P}
18	Is the work you are given by teachers usually pretty easy for you?	Emotional {E}
19	Do you feel it is difficult to begin learning something new?	Physical {P}
20	Do you find it difficult to focus on the details and put what you learn into practice?	Emotional {E}
21	Is it difficult for you to complete tasks when learning?	Emotional {E}
22	Do you usually begin new activities or tasks by reading instructions and then considering the learning materials at hand?	Physical {P}
23	Do you usually begin new activities or tasks by referring to the learning materials at hand and then reading instructions?	Mental {M}
24	Do you usually begin new activities or tasks by looking at the learning materials and then developing your own way of completing the task?	Emotional {E}
25	Do you usually relate a new activity or task to the skills you need to learn in order to complete the task?	Physical {P}
26	Do you usually begin a new learning process by relating it to other things you already know?	Mental {M}
27	Do you usually begin a new learning process by simply getting on with the activity?	Emotional {E}
28	If you were asked to learn something technical, would you prefer to begin by experimenting?	Emotional {E}
29	If you were asked to learn something technical, would you prefer to begin with verbal instructions from a teacher?	Mental {M}
30	If you were asked to learn something technical, would you prefer to begin by reading instructions?	Physical {P}
31	Do you prefer to learn new ideas and theories by discussing them with colleagues?	Mental {M}
32	Do you prefer to learn new ideas and theories by associating them with real-world applications?	Emotional {E}
33	Do you prefer to learn new ideas and theories by reading about them?	Physical {P}
34	Do you feel it is most important to be able to apply what you have learnt to something in real life?	Physical {P}
35	Do you feel it is most important to be able to demonstrate or explain what you have learnt to your colleagues and friends?	Mental {M}
36	Do you feel it is most important to be able to understand the core concepts of the subject you have learnt?	Mental {M}

3. Theory of Belief Functions

The theory of belief functions or the evidence theory can be described as a mathematical branch whose main concern is usually to apply several empirical evidence together so as to develop the actual picture in a person's thoughts or judgement process [15]. In other words, this theory tries to use mathematical inferences to help come up with a concrete reasoning on reality. Glenn Shafer who was an assistant professor and author of the book (A Mathematical Theory of Evidence) is often credited for helping to develop this theory as well as popularizing it but the real ideas behind the theory began with Arthur Dempster who was his senior professor [15]. This theory is mainly based on the fact that in both science as well as practical situations we are obliged to develop our reasoning based on facts that have to be supported using concrete evidence and in the case of this theory, the evidence is numerical [16]. The theory heavily employs the mathematical topic on probability to help come up with various decisions trees as the necessarily evidence required to prove a given reasoning or fact [17]. Figure 1 shows cognitive learning style diagnostic process. A key component of the theory of belief functions that we are interested in is how to combine independent sets of mass assignments. In our particular case, this would allow us to combine thirtysixth set of questions which have relevant level of knowledge the user has in a certain field.

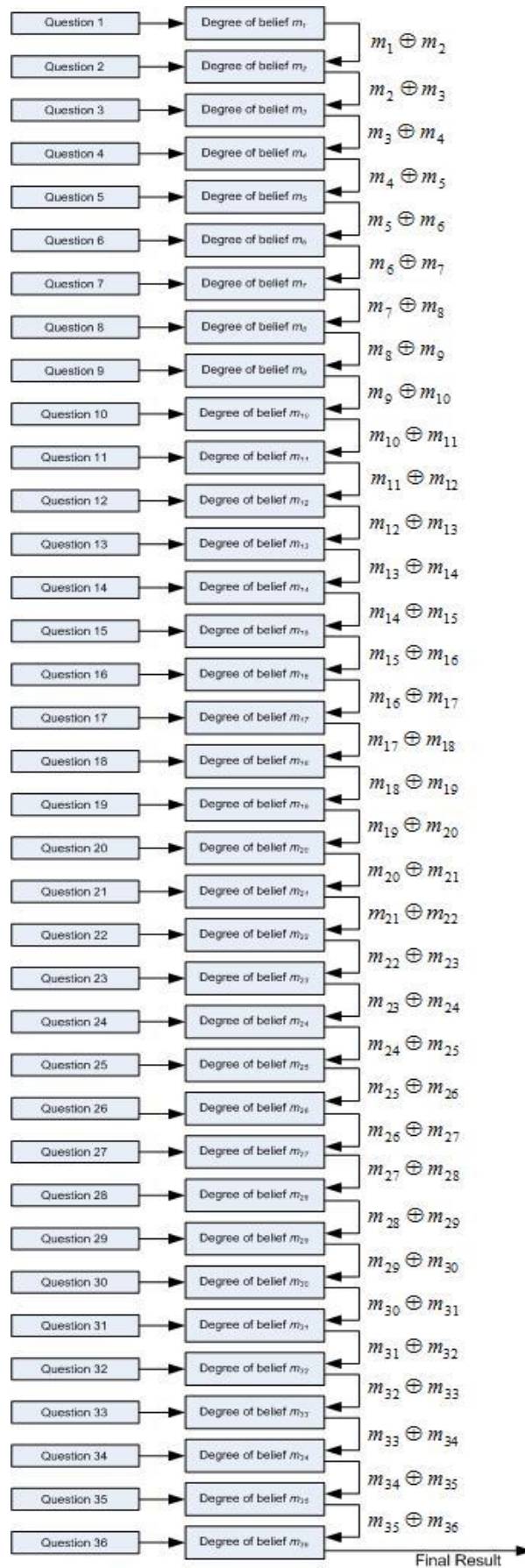


Figure 1. Cognitive learning style diagnostic process

The cognitive learning style diagnostic process begins with the questions. This section asks the user to answer a number of questions in order to assess their learning style. The theory of belief functions provide a rule to combine evidences from independent students and into a single and more informative hint. Evidence theory is based on belief function and plausible reasoning. First of all, we must define a frame of discernment, indicated by the sign Θ . The sign 2^Θ indicates the set composed of all the subset generated by the frame of discernment. For a hypothesis set, denoted by A , $m(A) \rightarrow [0,1]$. Theory of belief functions provide the method used to measure the evidences and combine the belief of different evidences [18] and mathematical theory of evidence could be described as follow:

$$\begin{aligned} m(\emptyset) &= 0 \\ \sum_{A \in 2^\Theta} m(A) &= 1 \end{aligned} \quad (1)$$

$\emptyset$ is the sign of an empty set. The function m is the degree of belief. Theory of belief functions combine two independent sets of mass assignments.

$$(m_1 \oplus m_2)(\emptyset) = 0 \quad (2)$$

$$(m_1 \oplus m_2)(A) = \frac{1}{1-K} \sum_{B \cap C = A} m_1(B) m_2(C) \quad (3)$$

Where

$$\begin{aligned} K &= \sum_{B \cap C = \emptyset} m_1(B) m_2(C) \\ m(A), m_1(B), m_2(C) &\rightarrow [0,1], A \neq \emptyset \end{aligned} \quad (4)$$

4. Implementation

Graf et al [19] identify the importance for an instructor to understand the learning styles of physical oriented since they may be able to gain much knowledge if their learning needs are not met appropriately. In most instances, most of the physical oriented learners develop difficulty in synthesizing new ideas and theories [20]. Often, they prefer reading about these ideas prior to learning them in a classroom setup. In several instances, the real life application of these ideas is an important component of their learning as it enables them to relate the knowledge acquired in class to real life situations [21]. The learning style comprise of kinesthetic and tactual learners. However, some of the learners are either tactual or kinesthetic.

Learning without prescriptive written instructions is another important component of emotional oriented cognition style of writing [22]. Under this case, the learner prefers to do extensive reading without the limitations of the instructor. In most instances, these learners spend much more time in the library carrying out literary research on various topics contrary to the physical oriented learners who only focus on the guidelines of that specific research work and only responds to the concerns as per the prescriptive written instructions. Due to the all-embracing research knowledge of the emotional oriented learners [23], they often find classroom assignments pretty easy and they take only a few hours to complete them. At times, they go an extra mile to provide additional information that exceeds what is actually required. These learners are often quick learners. Table 2 shows degree of belief of cognitive learning styles.

Table 2. Degree of belief of cognitive learning styles

No.	Cognitive Learning Style: Physical, Emotional, Mental Dimensions Question Sets	Physical/Mental/Emotional
1	Do you like to work on your own and take your time in your learning?	0.90
2	Do you attend specialist lectures or sessions to supplement your learning?	0.50
3	If you were given the opportunity, would you prefer one-on-one teaching sessions?	0.60
4	Do you learn best through practical examples and demonstrations?	0.80
5	Do you learn best when there is explanatory information provided to support your learning?	0.80

6	Do you learn best without prescriptive written instructions?	0.70
7	If you were given the choice, would you prefer to follow your own learning routine along your own schedule?	0.90
8	Do you prefer to follow clear guidelines when you are learning something new?	0.60
9	Do you prefer to develop your own routine without time restrictions when you learn?	0.50
10	Do you generally produce concise and useful information when you write?	0.80
11	When you write, do you generally produce many drafts before arriving at the final version?	0.60
12	Do you like to express your own opinions when you write?	0.50
13	When you are learning something new, do you like to relate the new topic to something you already know?	0.70
14	When you are learning something new, do you usually begin by forming a visual image of the topic?	0.60
15	When you are learning something new, do you like to begin by gathering as much information as possible?	0.70
16	Do you feel that beginning a new topic is a relatively easy process?	0.50
17	Do you usually focus on the practical details of what you have learnt?	0.40
18	Is the work you are given by teachers usually pretty easy for you?	0.80
19	Do you feel it is difficult to begin learning something new?	0.60
20	Do you find it difficult to focus on the details and put what you learn into practice?	0.40
21	Is it difficult for you to complete tasks when learning?	0.60
22	Do you usually begin new activities or tasks by reading instructions and then considering the learning materials at hand?	0.70
23	Do you usually begin new activities or tasks by referring to the learning materials at hand and then reading instructions?	0.50
24	Do you usually begin new activities or tasks by looking at the learning materials and then developing your own way of completing the task?	0.50
25	Do you usually relate a new activity or task to the skills you need to learn in order to complete the task?	0.80
26	Do you usually begin a new learning process by relating it to other things you already know?	0.60
27	Do you usually begin a new learning process by simply getting on with the activity?	0.70
28	If you were asked to learn something technical, would you prefer to begin by experimenting?	0.80
29	If you were asked to learn something technical, would you prefer to begin with verbal instructions from a teacher?	0.80
30	If you were asked to learn something technical, would you prefer to begin by reading instructions?	0.50
31	Do you prefer to learn new ideas and theories by discussing them with colleagues?	0.80
32	Do you prefer to learn new ideas and theories by associating them with real-world applications?	0.60
33	Do you prefer to learn new ideas and theories by reading about them?	0.70
34	Do you feel it is most important to be able to apply what you have learnt to something in real life?	0.80
35	Do you feel it is most important to be able to demonstrate or explain what you have learnt to your colleagues and friends?	0.70
36	Do you feel it is most important to be able to understand the core concepts of the subject you have learnt?	0.50

The cognitive learning style calculation process by the theory of belief functions is as follows:

1. Do you like to work on your own and take your time in your learning?
The first question says that student is mentally centred learner {M}, $m_1\{M\} = 0.90$
2. Do you attend specialist lectures or sessions to supplement your learning?
The second question says that student is mentally centred learner {M}, $m_2\{M\} = 0.50$

Table 3. Combining user's cognitive learning style 1 and 2

		{M}	0.50	{Θ}	0.50
{M}	0.90	{M}	0.45	{M}	0.45
{Θ}	0.10	{M}	0.05	{Θ}	0.05

We then calculate the combination of user's cognitive learning style 1 and 2 in order to get a new degree of belief of user's cognitive learning style 2.

$$m_3 \{M\} = 0.45 + 0.45 + 0.05/1-0 = 0.95, m_3 \{\Theta\} = 0.05/1-0 = 0.05$$

3. If you were given the opportunity, would you prefer one-on-one teaching sessions?

The third question says that student is mentally centred learner {M}, $m_4 \{M\} = 0.60$

Table 4. Combining user's cognitive learning style 2 and 3

		{M}	0.60	{Θ}	0.40
{M}	0.95	{M}	0.57	{M}	0.38
{Θ}	0.05	{M}	0.03	{Θ}	0.02

We then calculate the combination of user's cognitive learning style 2 and 3 in order to get a new degree of belief of user's cognitive learning style 2.

$$m_5 \{M\} = 0.57 + 0.38 + 0.03/1-0 = 0.98, m_5 \{\Theta\} = 0.02/1-0 = 0.02$$

4. Do you learn best through practical examples and demonstrations?

The fourth question says that student is physically centred learner {P}, $m_6 \{P\} = 0.80$

Table 5. Combining user's cognitive learning style 3 and 4

		{P}	0.80	{Θ}	0.20
{M}	0.98	{Θ}	0.784	{M}	0.196
{Θ}	0.02	{P}	0.016	{Θ}	0.004

We then calculate the combination of user's cognitive learning style 3 and 4 in order to get a new degree of belief of user's cognitive learning style 4.

$$m_7 \{M\} = 0.196/1-0.784 = 0.907, m_7 \{\Theta\} = 0.004/1-0.784 = 0.019$$

$$m_7 \{P\} = 0.016/1-0.784 = 0.074$$

5. Do you learn best when there is explanatory information provided to support your learning?

The fifth question says that student is physically centred learner {P}, $m_8 \{P\} = 0.80$

Table 6. Combining user's cognitive learning style 4 and 5

		{P}	0.80	{Θ}	0.20
{M}	0.907	{Θ}	0.726	{M}	0.181
{P}	0.074	{P}	0.059	{P}	0.015
{Θ}	0.019	{P}	0.015	{Θ}	0.004

We then calculate the combination of user's cognitive learning style 4 and 5 in order to get a new degree of belief of user's cognitive learning style 5.

$$m_9 \{M\} = 0.181/1-0.726 = 0.660, m_9 \{\Theta\} = 0.004/1-0.726 = 0.015$$

$$m_9 \{P\} = 0.059+0.015+0.015/1-0.726= 0.325$$

6. Do you learn best without prescriptive written instructions?

The sixth question says that student is emotional centred learner {E}, $m_{10}\{E\} = 0.70$

Table 7. Combining user's cognitive learning style 5 and 6

		{E}	0.70	{Θ}	0.30
{M}	0.660	{Ø}	0.462	{M}	0.198
{P}	0.325	{Ø}	0.228	{P}	0.098
{Θ}	0.015	{E}	0.011	{Θ}	0.005

We then calculate the combination of user's cognitive learning style 5 and 6 in order to get a new degree of belief of user's cognitive learning style 6.

$$m_{11}\{M\} = 0.198/1-0.462+0.228 = 0.639, m_{11}\{P\} = 0.098/1-0.462+0.228 = 0.316$$

$$m_{11}\{E\} = 0.011/1-0.462+0.228 = 0.035, m_{11}\{\Theta\} = 0.005/1-0.462+0.228 = 0.01$$

7. If you were given the choice, would you prefer to follow your own learning routine along your own schedule?

The seventh question says that student is mentally centred learner {M}, $m_{12}\{M\} = 0.90$

Table 8. Combining user's cognitive learning style 6 and 7

		{M}	0.90	{Θ}	0.10
{M}	0.639	{M}	0.575	{M}	0.064
{P}	0.316	{Ø}	0.284	{P}	0.032
{E}	0.035	{Ø}	0.032	{E}	0.004
{Θ}	0.01	{M}	0.009	{Θ}	0.001

We then calculate the combination of user's cognitive learning style 6 and 7 in order to get a new degree of belief of user's cognitive learning style 7.

$$m_{13}\{M\} = 0.575+0.064+0.009/1-0.284+0.032 = 0.947, m_{13}\{E\} = 0.004/1-0.284+0.032 = 0.005$$

$$m_{13}\{P\} = 0.032/1-0.284+0.032 = 0.047, m_{13}\{\Theta\} = 0.001/1-0.284+0.032 = 0.001$$

8. Do you prefer to follow clear guidelines when you are learning something new?

The eighth question says that student is physically centred learner {P}, $m_{14}\{P\} = 0.60$

Table 9. Combining user's cognitive learning style 7 and 8

		{P}	0.60	{Θ}	0.40
{M}	0.947	{Ø}	0.568	{M}	0.379
{P}	0.047	{P}	0.028	{P}	0.019
{E}	0.005	{Ø}	0.003	{E}	0.002
{Θ}	0.001	{P}	0.001	{Θ}	0.0004

We then calculate the combination of user's cognitive learning style 6 and 7 in order to get a new degree of belief of user's cognitive learning style 7.

$$m_{15}\{M\} = 0.379 / 1-(0.568+0.003) = 0.883, m_{15}\{E\} = 0.002/1-(0.568+0.003) = 0.004$$

$$m_{15}\{P\} = 0.028+0.019+0.001/1-(0.568+0.003) = 0.112, m_{15}\{\Theta\} = 0.0004/1-(0.568+0.003) = 0.001$$

9. Do you prefer to develop your own routine without time restrictions when you learn?

The ninth question says that student is mentally centred learner {M}, $m_{16}\{M\} = 0.50$

Table 10. Combining user's cognitive learning style 8 and 9

		{M}	0.50	{Θ}	0.50
{M}	0.883	{M}	0.442	{M}	0.442
{P}	0.112	{Ø}	0.056	{P}	0.056
{E}	0.004	{Ø}	0.002	{E}	0.002
{Θ}	0.001	{M}	0.0005	{Θ}	0.0005

We then calculate the combination of user's cognitive learning style 8 and 9 in order to get a new degree of belief of user's cognitive learning style 9.

$$m_{17} \{M\} = 0.442+0.442+0.0005 / 1-(0.056+0.002) = 0.938, m_{17} \{E\} = 0.002/1-(0.056+0.002) = 0.002$$

$$m_{17} \{P\} = 0.056/1-(0.056+0.002) = 0.059, m_{17} \{\Theta\} = 0.0005/1-(0.056+0.002) = 0.001$$

10. Do you generally produce concise and useful information when you write?

The tenth question says that student is mentally centred learner {M}, $m_{18} \{M\} = 0.80$

Table 11. Combining user's cognitive learning style 9 and 10

		{M}	0.80	{Θ}	0.20
{M}	0.938	{M}	0.750	{M}	0.188
{P}	0.059	{Ø}	0.047	{P}	0.012
{E}	0.002	{Ø}	0.002	{E}	0.0004
{Θ}	0.001	{M}	0.001	{Θ}	0.0002

We then calculate the combination of user's cognitive learning style 9 and 10 in order to get a new degree of belief of user's cognitive learning style 10.

$$m_{19} \{M\} = 0.750+0.188+0.001 / 1-(0.047+0.002) = 0.987, m_{19} \{E\} = 0.0004/1-(0.047+0.002) = 0.0004$$

$$m_{19} \{P\} = 0.012/1-(0.047+0.002) = 0.013, m_{19} \{\Theta\} = 0.0002/1-(0.047+0.002) = 0.0002$$

11. When you write, do you generally produce many drafts before arriving at the final version?

The eleventh question says that student is physically centred learner {P}, $m_{20} \{P\} = 0.60$

Table 12. Combining user's cognitive learning style 10 and 11

		{P}	0.60	{Θ}	0.40
{M}	0.987	{Ø}	0.592	{M}	0.394
{P}	0.013	{P}	0.007	{P}	0.005
{E}	0.004	{Ø}	0.002	{E}	0.001
{Θ}	0.0002	{P}	0.0001	{Θ}	0.0001

We then calculate the combination of user's cognitive learning style 10 and 11 in order to get a new degree of belief of user's cognitive learning style 11.

$$m_{21} \{M\} = 0.394 / 1-(0.592+0.002) = 0.970, m_{21} \{E\} = 0.001/1-(0.592+0.002) = 0.001$$

$$m_{21} \{P\} = 0.007+0.005+0.0001/1-(0.592+0.002) = 0.029, m_{21} \{\Theta\} = 0.0001/1-(0.592+0.002) = 0.0002$$

12. Do you like to express your own opinions when you write?

The twelfth question says that student is physically centred learner {P}, $m_{22} \{P\} = 0.50$

Table 13. Combining user's cognitive learning style 11 and 12

		{P}	0.50	{Θ}	0.50
{M}	0.970	{Ø}	0.485	{M}	0.485
{P}	0.029	{P}	0.014	{P}	0.014

{E}	0.001	{Ø}	0.0005	{E}	0.001
{Ø}	0.0002	{P}	0.0001	{Ø}	0.0001

We then calculate the combination of user's cognitive learning style 11 and 12 in order to get a new degree of belief of user's cognitive learning style 12.

$$m_{23} \{M\} = 0.485 / 1 - (0.485 + 0.0005) = 0.943, m_{23} \{E\} = 0.001 / 1 - (0.485 + 0.0005) = 0.002$$

$$m_{23} \{P\} = 0.014 + 0.014 + 0.0001 / 1 - (0.485 + 0.0005) = 0.055, m_{23} \{Ø\} = 0.0001 / 1 - (0.485 + 0.0005) = 0.0002$$

13. When you are learning something new, do you like to relate the new topic to something you already know?

The thirteenth question says that student is physically centred learner {P}, $m_{24} \{P\} = 0.70$

Table 14. Combining user's cognitive learning style 12 and 13

		{P}	0.70	{Ø}	0.30
{M}	0.943	{Ø}	0.660	{M}	0.283
{P}	0.055	{P}	0.039	{P}	0.016
{E}	0.002	{Ø}	0.001	{E}	0.001
{Ø}	0.0002	{P}	0.0001	{Ø}	0.0001

We then calculate the combination of user's cognitive learning style 12 and 13 in order to get a new degree of belief of user's cognitive learning style 13.

$$m_{25} \{M\} = 0.283 / 1 - (0.660 + 0.001) = 0.835, m_{25} \{E\} = 0.001 / 1 - (0.660 + 0.001) = 0.003$$

$$m_{25} \{P\} = 0.039 + 0.016 + 0.0001 / 1 - (0.660 + 0.001) = 0.162, m_{25} \{Ø\} = 0.0001 / 1 - (0.660 + 0.001) = 0.0003$$

14. When you are learning something new, do you usually begin by forming a visual image of the topic?

The fourteenth question says that student is mentally centred learner {M}, $m_{26} \{M\} = 0.60$

Table 15. Combining user's cognitive learning style 13 and 14

		{M}	0.60	{Ø}	0.40
{M}	0.835	{M}	0.501	{M}	0.334
{P}	0.162	{Ø}	0.097	{P}	0.065
{E}	0.003	{Ø}	0.002	{E}	0.001
{Ø}	0.0003	{M}	0.0002	{Ø}	0.0001

We then calculate the combination of user's cognitive learning style 13 and 14 in order to get a new degree of belief of user's cognitive learning style 14.

$$m_{27} \{M\} = 0.501 + 0.334 + 0.0002 / 1 - (0.097 + 0.002) = 0.927, m_{27} \{E\} = 0.001 / 1 - (0.097 + 0.002) = 0.001$$

$$m_{27} \{P\} = 0.065 / 1 - (0.097 + 0.002) = 0.072, m_{27} \{Ø\} = 0.0001 / 1 - (0.097 + 0.002) = 0.0001$$

15. When you are learning something new, do you like to begin by gathering as much information as possible?

The fifteenth question says that student is mentally centred learner {M}, $m_{28} \{M\} = 0.70$

Table 16. Combining user's cognitive learning style 14 and 15

		{M}	0.70	{Ø}	0.30
{M}	0.927	{M}	0.649	{M}	0.278
{P}	0.072	{Ø}	0.050	{P}	0.022
{E}	0.001	{Ø}	0.001	{E}	0.0003
{Ø}	0.0001	{M}	0.0001	{Ø}	0.00003

We then calculate the combination of user's cognitive learning style 14 and 15 in order to get a new degree of belief of user's cognitive learning style 15.

$$m_{29} \{M\} = 0.649 + 0.278 + 0.0001 / 1 - (0.050 + 0.001) = 0.977, \quad m_{29} \{E\} = 0.0003 / 1 - (0.050 + 0.001) = 0.0003$$

$$m_{29} \{P\} = 0.022 / 1 - (0.050 + 0.001) = 0.023, \quad m_{29} \{\Theta\} = 0.00003 / 1 - (0.050 + 0.001) = 0.00003$$

16. Do you feel that beginning a new topic is a relatively easy process?

The sixteenth question says that student is emotional centred learner {E}, $m_{30} \{E\} = 0.50$

Table 17. Combining user's cognitive learning style 15 and 16

		{E}	0.50	{Θ}	0.50
{M}	0.977	{Ø}	0.488	{M}	0.488
{P}	0.023	{Ø}	0.012	{P}	0.012
{E}	0.0003	{E}	0.0002	{E}	0.0002
{Θ}	0.00003	{E}	0.00002	{Θ}	0.00002

We then calculate the combination of user's cognitive learning style 15 and 16 in order to get a new degree of belief of user's cognitive learning style 16.

$$m_{31} \{M\} = 0.488 / 1 - (0.488 + 0.012) = 0.976, \quad m_{31} \{E\} = 0.0002 + 0.0002 + 0.00002 / 1 - (0.488 + 0.012) = 0.0008$$

$$m_{31} \{P\} = 0.012 / 1 - (0.488 + 0.012) = 0.024, \quad m_{31} \{\Theta\} = 0.00002 / 1 - (0.488 + 0.012) = 0.00004$$

17. Do you usually focus on the practical details of what you have learnt?

The seventeenth question says that student is physically centred learner {P}, $m_{32} \{P\} = 0.40$

Table 18. Combining user's cognitive learning style 16 and 17

		{P}	0.40	{Θ}	0.60
{M}	0.976	{Ø}	0.390	{M}	0.586
{P}	0.024	{P}	0.009	{P}	0.014
{E}	0.0008	{Ø}	0.0003	{E}	0.0005
{Θ}	0.00004	{P}	0.00002	{Θ}	0.00002

We then calculate the combination of user's cognitive learning style 16 and 17 in order to get a new degree of belief of user's cognitive learning style 17.

$$m_{33} \{M\} = 0.586 / 1 - (0.390 + 0.0003) = 0.96, \quad m_{33} \{E\} = 0.0005 / 1 - (0.390 + 0.0003) = 0.001$$

$$m_{33} \{P\} = 0.009 + 0.014 + 0.00002 / 1 - (0.390 + 0.0003) = 0.039, \quad m_{33} \{\Theta\} = 0.00002 / 1 - (0.390 + 0.0003) = 0.00003$$

18. Is the work you are given by teachers usually pretty easy for you?

The eighteenth question says that student is emotional centred learner {E}, $m_{34} \{E\} = 0.80$

Table 19. Combining user's cognitive learning style 17 and 18

		{E}	0.80	{Θ}	0.20
{M}	0.96	{Ø}	0.768	{M}	0.192
{P}	0.039	{Ø}	0.031	{P}	0.008
{E}	0.001	{E}	0.0008	{E}	0.0002
{Θ}	0.00003	{E}	0.00002	{Θ}	0.00001

We then calculate the combination of user's cognitive learning style 17 and 18 in order to get a new degree of belief of user's cognitive learning style 18.

$$m_{35} \{M\} = 0.192/1-(0.768+0.031) = 0.955, m_{35} \{E\} = 0.0008+0.0002+0.00002/1-(0.768+0.031) = 0.005$$

$$m_{35} \{P\} = 0.008/1-(0.768+0.031) = 0.040, m_{35} \{\Theta\} = 0.00001/1-(0.768+0.031) = 0.00004$$

19. Do you feel it is difficult to begin learning something new?

The nineteenth question says that student is physically centred learner {P}, $m_{36} \{P\} = 0.60$

Table 20. Combining user's cognitive learning style 18 and 19

		{P}	0.60	{Θ}	0.40
{M}	0.955	{Ø}	0.537	{M}	0.382
{P}	0.040	{P}	0.024	{P}	0.016
{E}	0.005	{Ø}	0.003	{E}	0.002
{Θ}	0.00004	{P}	0.00002	{Θ}	0.00002

We then calculate the combination of user's cognitive learning style 18 and 19 in order to get a new degree of belief of user's cognitive learning style 19.

$$m_{37} \{M\} = 0.382/1-(0.573+0.003) = 0.901, m_{37} \{E\} = 0.002/1-(0.537+0.003) = 0.005$$

$$m_{37} \{P\} = 0.024+0.016+0.00002/1-(0.537+0.003) = 0.094, m_{37} \{\Theta\} = 0.00002/1-(0.537+0.003) = 0.00005$$

20. Do you find it difficult to focus on the details and put what you learn into practice?

The twentieth question says that student is emotional centred learner {E}, $m_{38} \{E\} = 0.40$

Table 21. Combining user's cognitive learning style 19 and 20

		{E}	0.40	{Θ}	0.60
{M}	0.901	{Ø}	0.360	{M}	0.541
{P}	0.094	{Ø}	0.038	{P}	0.056
{E}	0.005	{E}	0.002	{E}	0.003
{Θ}	0.00005	{E}	0.00002	{Θ}	0.00003

We then calculate the combination of user's cognitive learning style 19 and 20 in order to get a new degree of belief of user's cognitive learning style 20.

$$m_{39} \{M\} = 0.541/1-(0.360+0.038) = 0.899, m_{39} \{E\} = 0.002+0.003+0.00002/1-(0.360+0.038) = 0.008$$

$$m_{39} \{P\} = 0.056/1-(0.360+0.038) = 0.093, m_{39} \{\Theta\} = 0.00003/1-(0.360+0.038) = 0.00005$$

21. Is it difficult for you to complete tasks when learning?

The twenty-first question says that student is emotional centred learner {E}, $m_{40} \{E\} = 0.60$

Table 22. Combining user's cognitive learning style 20 and 21

		{E}	0.60	{Θ}	0.40
{M}	0.899	{Ø}	0.539	{M}	0.360
{P}	0.093	{Ø}	0.056	{P}	0.037
{E}	0.008	{E}	0.005	{E}	0.003
{Θ}	0.00005	{E}	0.00003	{Θ}	0.00002

We then calculate the combination of user's cognitive learning style 20 and 21 in order to get a new degree of belief of user's cognitive learning style 21.

$$m_{41} \{M\} = 0.360/1-(0.539+0.056) = 0.889, m_{41} \{E\} = 0.005+0.003+0.00003/1-(0.539+0.056) = 0.020$$

$$m_{41}\{P\} = 0.037/1-(0.539+0.056) = 0.091, m_{41}\{\Theta\} = 0.00002/1-(0.539+0.056) = 0.00005$$

22. Do you usually begin new activities or tasks by reading instructions and then considering the learning materials at hand?

The twenty-two question says that student is physically centred learner $\{P\}$, $m_{42}\{P\} = 0.70$

Table 23. Combining user's cognitive learning style 21 and 22

		{P}	0.70	{Θ}	0.30
{M}	0.889	{Ø}	0.622	{M}	0.267
{P}	0.091	{P}	0.064	{P}	0.027
{E}	0.020	{Ø}	0.014	{E}	0.006
{Θ}	0.00005	{P}	0.00004	{Θ}	0.00001

We then calculate the combination of user's cognitive learning style 21 and 22 in order to get a new degree of belief of user's cognitive learning style 22.

$$m_{43}\{M\} = 0.267/1-(0.622+0.014) = 0.734, m_{43}\{E\} = 0.006/1-(0.622+0.014) = 0.016$$

$$m_{43}\{P\} = 0.064+0.027+0.00004/1-(0.622+0.014) = 0.250, m_{43}\{\Theta\} = 0.00001/1-(0.622+0.014) = 0.00003$$

23. Do you usually begin new activities or tasks by referring to the learning materials at hand and then reading instructions?

The twenty-third question says that student is mentally centred learner $\{M\}$, $m_{44}\{M\} = 0.50$

Table 24. Combining user's cognitive learning style 22 and 23

		{M}	0.50	{Θ}	0.50
{M}	0.734	{M}	0.367	{M}	0.367
{P}	0.250	{Ø}	0.125	{P}	0.125
{E}	0.016	{Ø}	0.008	{E}	0.008
{Θ}	0.00003	{M}	0.00001	{Θ}	0.00001

We then calculate the combination of user's cognitive learning style 22 and 23 in order to get a new degree of belief of user's cognitive learning style 23.

$$m_{45}\{M\} = 0.367+0.367+0.00001/1-(0.125+0.008) = 0.847, m_{45}\{E\} = 0.008/1-(0.125+0.008) = 0.009,$$

$$m_{45}\{P\} = 0.125/1-(0.125+0.008) = 0.144, m_{45}\{\Theta\} = 0.00001/1-(0.125+0.008) = 0.00001$$

24. Do you usually begin new activities or tasks by looking at the learning materials and then developing your own way of completing the task?

The twenty-fourth question says that student is emotional centred learner $\{E\}$, $m_{46}\{E\} = 0.50$

Table 25. Combining user's cognitive learning style 23 and 24

		{E}	0.50	{Θ}	0.50
{M}	0.847	{Ø}	0.424	{M}	0.424
{P}	0.144	{Ø}	0.072	{P}	0.072
{E}	0.009	{E}	0.004	{E}	0.004
{Θ}	0.00001	{E}	0.00001	{Θ}	0.00001

We then calculate the combination of user's cognitive learning style 23 and 24 in order to get a new degree of belief of user's cognitive learning style 24.

$$m_{47} \{M\} = 0.424/1-(0.424+0.072) = 0.841, m_{47} \{E\} = 0.004+0.004+0.00001/1-(0.424+0.072) = 0.016,$$

$$m_{47} \{P\} = 0.072/1-(0.424+0.072) = 0.143, m_{47} \{\emptyset\} = 0.00001/1-(0.424+0.072) = 0.00002$$

25. Do you usually relate a new activity or task to the skills you need to learn in order to complete the task?
The twenty-fifth question says that student is physically centred learner {P}, $m_{48} \{P\} = 0.80$

Table 26. Combining user's cognitive learning style 24 and 25

		{P}	0.80	{\emptyset}	0.20
{M}	0.841	{\emptyset}	0.673	{M}	0.168
{P}	0.143	{P}	0.114	{P}	0.029
{E}	0.016	{\emptyset}	0.013	{E}	0.003
{\emptyset}	0.00002	{P}	0.00002	{\emptyset}	0.000004

We then calculate the combination of user's cognitive learning style 24 and 25 in order to get a new degree of belief of user's cognitive learning style 25.

$$m_{49} \{M\} = 0.168/1-(0.673+0.013) = 0.535, m_{49} \{E\} = 0.003/1-(0.673+0.013) = 0.010,$$

$$m_{49} \{P\} = 0.114+0.029+0.00002/1-(0.673+0.013) = 0.455, m_{49} \{\emptyset\} = 0.000004/1-(0.673+0.013) = 0.00001$$

26. Do you usually begin a new learning process by relating it to other things you already know?
The twenty-sixth question says that student is mentally centred learner {M}, $m_{50} \{M\} = 0.60$

Table 27. Combining user's cognitive learning style 25 and 26

		{M}	0.60	{\emptyset}	0.40
{M}	0.535	{M}	0.321	{M}	0.214
{P}	0.455	{\emptyset}	0.273	{P}	0.182
{E}	0.010	{\emptyset}	0.006	{E}	0.004
{\emptyset}	0.00001	{M}	0.00001	{\emptyset}	0.000004

We then calculate the combination of user's cognitive learning style 25 and 26 in order to get a new degree of belief of user's cognitive learning style 26.

$$m_{51} \{M\} = 0.321+0.214+0.00001/1-(0.273+0.006) = 0.742, m_{51} \{E\} = 0.004/1-(0.273+0.006) = 0.006,$$

$$m_{51} \{P\} = 0.182/1-(0.273+0.006) = 0.252, m_{51} \{\emptyset\} = 0.000004/1-(0.273+0.006) = 0.000005$$

27. Do you usually begin a new learning process by simply getting on with the activity?
The twenty-seventh question says that student is emotional centred learner {E}, $m_{52} \{E\} = 0.70$

Table 28. Combining user's cognitive learning style 26 and 27

		{E}	0.70	{\emptyset}	0.30
{M}	0.742	{\emptyset}	0.519	{M}	0.223
{P}	0.252	{\emptyset}	0.176	{P}	0.076
{E}	0.006	{E}	0.004	{E}	0.002
{\emptyset}	0.000005	{E}	0.000004	{\emptyset}	0.000002

We then calculate the combination of user's cognitive learning style 26 and 27 in order to get a new degree of belief of user's cognitive learning style 27.

$$m_{53} \{M\} = 0.223/1-(0.519+0.176) = 0.731, m_{53} \{E\} = 0.004+0.002+0.000004/1-(0.519+0.176) = 0.020,$$

$$m_{53} \{P\} = 0.076/1-(0.519+0.176) = 0.249, m_{53} \{\emptyset\} = 0.000002/1-(0.519+0.176) = 0.000007$$

28. If you were asked to learn something technical, would you prefer to begin by experimenting?
The twenty-eighth question says that student is emotional centred learner {E}, $m_{54}\{E\} = 0.80$

Table 29. Combining user's cognitive learning style 27 and 28

		{E}	0.80	{Θ}	0.20
{M}	0.731	{Ø}	0.585	{M}	0.146
{P}	0.249	{Ø}	0.199	{P}	0.050
{E}	0.020	{E}	0.016	{E}	0.004
{Θ}	0.000007	{E}	0.000006	{Θ}	0.0000014

We then calculate the combination of user's cognitive learning style 27 and 28 in order to get a new degree of belief of user's cognitive learning style 28.

$$m_{55}\{M\} = 0.146/1-(0.585+0.199) = 0.676, m_{55}\{E\} = 0.016+0.004+0.000006/1-(0.585+0.199) = 0.093,$$

$$m_{55}\{P\} = 0.050/1-(0.585+0.199) = 0.231, m_{55}\{\Theta\} = 0.0000014/1-(0.585+0.199) = 0.0000006$$

29. If you were asked to learn something technical, would you prefer to begin with verbal instructions from a teacher?

The twenty-ninth question says that student is mentally centred learner {M}, $m_{56}\{M\} = 0.80$

Table 30. Combining user's cognitive learning style 28 and 29

		{M}	0.80	{Θ}	0.20
{M}	0.676	{M}	0.541	{M}	0.135
{P}	0.231	{Ø}	0.185	{P}	0.046
{E}	0.093	{Ø}	0.074	{E}	0.019
{Θ}	0.000006	{M}	0.000005	{Θ}	0.000001

We then calculate the combination of user's cognitive learning style 28 and 29 in order to get a new degree of belief of user's cognitive learning style 29.

$$m_{57}\{M\} = 0.541+0.135+0.000005/1-(0.185+0.074) = 0.912, m_{57}\{E\} = 0.019/1-(0.185+0.074) = 0.026,$$

$$m_{57}\{P\} = 0.046/1-(0.185+0.074) = 0.062, m_{57}\{\Theta\} = 0.000001/1-(0.185+0.074) = 0.000001$$

30. If you were asked to learn something technical, would you prefer to begin by reading instructions?
The thirtieth says that student is physically centred learner {P}, $m_{58}\{P\} = 0.50$

Table 31. Combining user's cognitive learning style 29 and 30

		{P}	0.50	{Θ}	0.50
{M}	0.912	{Ø}	0.456	{M}	0.456
{P}	0.062	{P}	0.031	{P}	0.031
{E}	0.026	{Ø}	0.013	{E}	0.013
{Θ}	0.000001	{P}	0.0000005	{Θ}	0.0000005

We then calculate the combination of user's cognitive learning style 28 and 29 in order to get a new degree of belief of user's cognitive learning style 29.

$$m_{59}\{M\} = 0.456/1-(0.456+0.013) = 0.859, m_{59}\{E\} = 0.013/1-(0.456+0.013) = 0.024,$$

$$m_{59}\{P\} = 0.031+0.031+0.0000005/1-(0.456+0.013) = 0.117, m_{59}\{\Theta\} = 0.0000005/1-(0.456+0.013) = 0.000001$$

31. Do you prefer to learn new ideas and theories by discussing them with colleagues?

The thirty-first question says that student is mentally centred learner {M}, $m_{60}\{M\} = 0.80$

Table 32. Combining user's cognitive learning style 30 and 31

		{M}	0.80	{Θ}	0.20
{M}	0.859	{M}	0.687	{M}	0.172
{P}	0.117	{Ø}	0.094	{P}	0.023
{E}	0.024	{Ø}	0.019	{E}	0.005
{Θ}	0.000001	{M}	0.0000008	{Θ}	0.0000002

We then calculate the combination of user's cognitive learning style 30 and 31 in order to get a new degree of belief of user's cognitive learning style 31.

$$m_{61}\{M\} = 0.687 + 0.172 + 0.0000008 / 1 - (0.094 + 0.019) = 0.968, m_{61}\{E\} = 0.005 / 1 - (0.094 + 0.019) = 0.006,$$

$$m_{61}\{P\} = 0.023 / 1 - (0.094 + 0.019) = 0.026, m_{61}\{\Theta\} = 0.0000002 / 1 - (0.094 + 0.019) = 0.0000002$$

32. Do you prefer to learn new ideas and theories by associating them with real-world applications?
The thirty-second question says that student is emotional centred learner {E}, $m_{62}\{E\} = 0.60$

Table 33. Combining user's cognitive learning style 31 and 32

		{E}	0.60	{Θ}	0.40
{M}	0.968	{Ø}	0.581	{M}	0.387
{P}	0.026	{Ø}	0.016	{P}	0.010
{E}	0.006	{E}	0.004	{E}	0.002
{Θ}	0.0000002	{E}	0.00000012	{Θ}	0.00000008

We then calculate the combination of user's cognitive learning style 31 and 32 in order to get a new degree of belief of user's cognitive learning style 32.

$$m_{63}\{M\} = 0.387 / 1 - (0.581 + 0.016) = 0.960, m_{63}\{E\} = 0.004 + 0.002 + 0.00000012 / 1 - (0.581 + 0.016) = 0.015,$$

$$m_{63}\{P\} = 0.010 / 1 - (0.581 + 0.016) = 0.025, m_{63}\{\Theta\} = 0.00000008 / 1 - (0.581 + 0.016) = 0.00000002$$

33. Do you prefer to learn new ideas and theories by reading about them?
The thirty-third question says that student is physically centred learner {P}, $m_{64}\{P\} = 0.70$

Table 34. Combining user's cognitive learning style 32 and 33

		{P}	0.70	{Θ}	0.30
{M}	0.960	{Ø}	0.672	{M}	0.288
{P}	0.025	{P}	0.017	{P}	0.007
{E}	0.015	{Ø}	0.010	{E}	0.005
{Θ}	0.00000002	{P}	0.000000014	{Θ}	0.000000006

We then calculate the combination of user's cognitive learning style 32 and 33 in order to get a new degree of belief of user's cognitive learning style 33.

$$m_{65}\{M\} = 0.288 / 1 - (0.672 + 0.010) = 0.905, m_{65}\{E\} = 0.005 / 1 - (0.672 + 0.010) = 0.015,$$

$$m_{65}\{P\} = 0.017 + 0.007 + 0.000000014 / 1 - (0.672 + 0.010) = 0.080, m_{65}\{\Theta\} = 0.000000006 / 1 - (0.672 + 0.010) = 0.00000002$$

34. Do you feel it is most important to be able to apply what you have learnt to something in real life?
The thirty-fourth question says that student is physically centred learner {P}, $m_{66}\{P\} = 0.80$

Table 35. Combining user's cognitive learning style 33 and 34

		{P}	0.80	{Θ}	0.20
{M}	0.905	{Ø}	0.724	{M}	0.181
{P}	0.080	{P}	0.064	{P}	0.016

{E}	0.015	{Ø}	0.012	{E}	0.003
{Ø}	0.00000002	{P}	0.000000016	{Ø}	0.000000004

We then calculate the combination of user's cognitive learning style 33 and 34 in order to get a new degree of belief of user's cognitive learning style 34.

$$m_{67} \{M\} = 0.181/1-(0.724+0.012) = 0.686, m_{67} \{E\} = 0.003/1-(0.724+0.012) = 0.011,$$

$$m_{67} \{P\} = 0.064+0.016+0.000000016/1-(0.724+0.012) = 0.303, m_{67} \{\Theta\} = 0.000000004/1-(0.724+0.012) = 0.000000015$$

35. Do you feel it is most important to be able to demonstrate or explain what you have learnt to your colleagues and friends?

The thirty-fifth question says that student is mentally centred learner $\{M\}$, $m_{68}\{M\} = 0.70$

Table 36. Combining user's cognitive learning style 34 and 35

		{M}	0.70	{Ø}	0.30
{M}	0.686	{M}	0.480	{M}	0.206
{P}	0.303	{Ø}	0.212	{P}	0.091
{E}	0.011	{Ø}	0.008	{E}	0.003
{Ø}	0.000000015	{M}	0.0000000105	{Ø}	0.0000000045

We then calculate the combination of user's cognitive learning style 34 and 35 in order to get a new degree of belief of user's cognitive learning style 35.

$$m_{69} \{M\} = 0.480+0.206+0.0000000105/1-(0.212+0.008) = 0.879, m_{69} \{E\} = 0.003/1-(0.212+0.008) = 0.004$$

$$m_{69} \{P\} = 0.091/1-(0.212+0.008) = 0.117, m_{69} \{\Theta\} = 0.0000000045/1-(0.212+0.008) = 0.0000000058$$

36. Do you feel it is most important to be able to understand the core concepts of the subject you have learnt?

The thirty-sixth question says that student is mentally centred learner $\{M\}$, $m_{70}\{M\} = 0.50$

Table 37. Combining user's cognitive learning style 35 and 36

		{M}	0.50	{Ø}	0.50
{M}	0.879	{M}	0.440	{M}	0.440
{P}	0.117	{Ø}	0.058	{P}	0.058
{E}	0.004	{Ø}	0.002	{E}	0.002
{Ø}	0.0000000058	{M}	0.0000000029	{Ø}	0.0000000029

We then calculate the combination of user's cognitive learning style 35 and 36 in order to get a new degree of belief of user's cognitive learning style 36.

$$m_{69} \{M\} = 0.440+0.440+0.0000000029/1-(0.058+0.002) = 0.936, m_{69} \{E\} = 0.002/1-(0.058+0.002) = 0.002$$

$$m_{69} \{P\} = 0.058/1-(0.058+0.002) = 0.062, m_{69} \{\Theta\} = 0.0000000029/1-(0.058+0.002) = 0.000000003$$

From the last calculation we get mentally oriented > physically oriented > emotionally oriented. Student is mentally centred learner.

5. Results and Discussion

We have categorised learners into three types: "physically oriented", "emotionally oriented", and "mentally oriented". This form of categorisation is supported by European research from Riding and Cheema Cognitive Styles Analysis (CSA), and the Wholist-Analytical (WA) dimension. In addition,

extensive research has been conducted on learning styles by Dunn & Dunn [24][25][26] and specifically on multiculturalism and learning styles in the Americas by Dunn & Griggs [27].

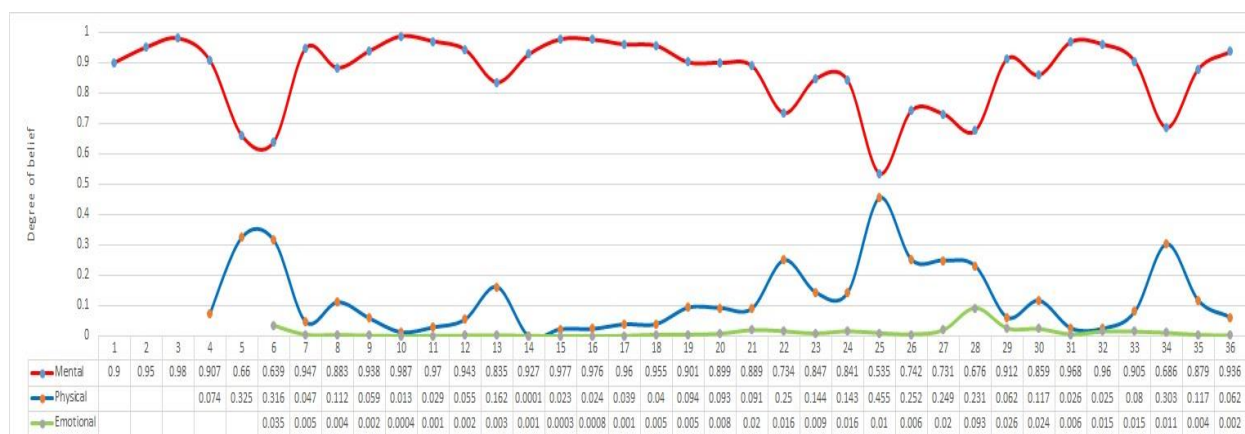


Figure 2. Cognitive learning styles diagnostic

Figure 2 shows degree of belief progress in cognitive learning styles diagnostic. From the 36th calculation we get mentally learner 93.6%, physically learner 6.2%, and emotionally learner 2%. Mentally learners are known for their conciseness and usefulness of the information that they produce [28]. They tend to produce final write-ups without necessarily making many drafts as in the case of learners in the physical oriented cognitive style of learning. Many at a times, these learners are unique in that they tend to form a visual image of the topic under study as they begin to learn something new. This is important in internalizing the concept under study [28]. Furthermore, as they begin doing new tasks they first critically examine the materials used the task before reading through the instructions. Nevertheless, in technical studies, these learners first get verbal instructions from the instructor before proceeding to read the instructions. Also, they discuss new ideas and theories with colleagues to get an extensive requirement for any task. In addition, learners who employ this style of learning develop the confidence of presenting his or her findings with colleagues and friends. Importantly, these learners are capable of explaining core concepts of the subject learnt more effectively. Table 38 shows cognitive learning styles rank.

Table 38. Cognitive learning styles rank

No	Mental		Physical		Emotional
1	0.9	>	Null	=	Null
2	0.95	>	Null	=	Null
3	0.98	>	Null	=	Null
4	0.907	>	0.074	>	Null
5	0.66	>	0.325	>	Null
6	0.639	>	0.316	>	0.035
7	0.947	>	0.047	>	0.005
8	0.883	>	0.112	>	0.004
9	0.938	>	0.059	>	0.002
10	0.987	>	0.013	>	0.0004
11	0.97	>	0.029	>	0.001
12	0.943	>	0.055	>	0.002
13	0.835	>	0.162	>	0.003
14	0.927	>	0.072	>	0.001
15	0.977	>	0.023	>	0.0003
16	0.976	>	0.024	>	0.0008
17	0.96	>	0.039	>	0.001

18	0.955	>	0.04	>	0.005
19	0.901	>	0.094	>	0.005
20	0.899	>	0.093	>	0.008
21	0.889	>	0.091	>	0.02
22	0.734	>	0.25	>	0.016
23	0.847	>	0.144	>	0.009
24	0.841	>	0.143	>	0.016
25	0.535	>	0.455	>	0.01
26	0.742	>	0.252	>	0.006
27	0.731	>	0.249	>	0.02
28	0.676	>	0.231	>	0.093
29	0.912	>	0.062	>	0.026
30	0.859	>	0.117	>	0.024
31	0.968	>	0.026	>	0.006
32	0.96	>	0.025	>	0.015
33	0.905	>	0.080	>	0.015
34	0.686	>	0.303	>	0.011
35	0.879	>	0.117	>	0.004
36	0.936	>	0.062	>	0.002

Most learners who apply physical cognition in their learning are always slow learners who would take their time in doing a task repeatedly over time to produce the best outcome of it [13]. For instance, if that writer is completing an essay, then he or she would make two or three drafts before making the final draft. Zhang, Sternberg & Rayner [20] denotes that the physical oriented cognitive style of writing has been known to be one of the most effective learning style among children aged between 2 and 6 years old. [29] Olmstead and Kuhlmeier [29] reiterates that these children are able to carry out certain problem solving tasks on their own and eventually retains much information for several years in their study life. In the process of learning, physical oriented cognitive learners use practical means to perceive, interact with as well as respond to the requirements of an assessment or as guided by his or her instructor [30].

Emotional oriented cognitive style of learning has been important in experimenting new ideas before they are actually studied and analyzed [31]. Most of emotional oriented learners tend to focus extensively on experimenting as a forefront to acquiring additional about any given idea or theory. Also, [31] notes that these learners are able to carry out technical studies on their own as long as they are able to complete its initial experimenting stage effectively. The style of learning as Sense [13] points out has been emerging as a new style of learning that is capable of replacing the involvement of the instructor in almost all the stages of learning. These learners are social and are able to form groups which enable them to discuss the diverse perspectives involved in completing a task on their own and complete it appropriately without the intervention of an instructor. One of the key significant feature of these learners is their ability to read extensively without limiting their knowledge acquisition to the provisions and guidelines of the instructor [20]. Therefore, it has been useful tool for learning, especially among learners who undertake distance or virtual learning.

6. Conclusion

To conclude the paper identifies how theory of belief functions can diagnose cognitive learning style. Physically centred learners learn best by observing and/or doing. They will need very limited verbal instruction but will require suitable time for both practice and completion of an activity. Ideally, the content of an activity should be practical and pertinent to the learner's own life. Collaboration through co-operation with others can also be very effective in supporting the learning process. Emotional/relational learners operate best by listening to others and discussing the activity with others. They work most efficiently by relating the activity to their own lives and when the learning process is supported by a

relaxed atmosphere. Emotional/relational learners are typically able to deal with multiple activities while learning something new. They may find reassurance in saying what they know out loud to others. Mentally centred learners absorb information by focusing on the idea or theory of the activity. They learn best when the subject concerns something they value. Typically, they are independent learners; however, they enjoy talking about ideas and viewpoints with others. Mentally centred learners concentrate deeply on specific learning tasks and find it difficult to divide attention in order to listen or watch other activities at the same time. The conclusion made is that we can be able to easily diagnose cognitive learning style using the theory of belief functions.

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References

- [1] Darder, A., Hernandez, K., Lam, K. D., & Baltodano, M. (2023). Critical pedagogy: An introduction. In *The critical pedagogy reader* (pp. 1-30). Routledge.
- [2] Costa, R. D., Souza, G. F., Valentim, R. A., & Castro, T. B. (2020). The theory of learning styles applied to distance learning. *Cognitive Systems Research*, 64, 134-145.
- [3] Lwande, C., Muchemi, L., & Oboko, R. (2021). Identifying learning styles and cognitive traits in a learning management system. *Heliyon*, 7(8).
- [4] Huang, C. L., Luo, Y. F., Yang, S. C., Lu, C. M., & Chen, A. S. (2020). Influence of students' learning style, sense of presence, and cognitive load on learning outcomes in an immersive virtual reality learning environment. *Journal of Educational Computing Research*, 58(3), 596-615.
- [5] Chen, M. R. A., & Hwang, G. J. (2022). Effects of experiencing authentic contexts on English speaking performances, anxiety and motivation of EFL students with different cognitive styles. *Interactive Learning Environments*, 30(9), 1619-1639.
- [6] Sandri, O. (2022). What do we mean by 'pedagogy' in sustainability education?. *Teaching in Higher Education*, 27(1), 114-129.
- [7] Olson, M. H., & Ramírez, J. J. (2020). *An introduction to theories of learning*. Routledge.
- [8] Moushir M. El-Bishouty, Ting-Wen Chang, Renan Lima, Mohamed B. Thaha, Kinshuk, and Sabine Graf (2015). Analyzing learner characteristics and courses based on cognitive abilities, learning styles and context. In M. Chang and Y. Li (Eds.), *Smart Learning Environments. Lecture Notes in Educational Technology*, Springer, New York, pp. 3-25
- [9] Shettleworth, S. (2010). *Cognition, Evolution and Behaviour*. UK: Oxford University Press.
- [10] Eisenberg, N. (2014). *Altruistic Emotion, Cognition, and Behavior (PLE: Emotion)*. USA: Psychology Press.
- [11] Olmstead, M and Kuhlmeier, V. (2015). *Comparative Cognition*. UK: Cambridge University Press.
- [12] Rayner, S. G. (2015). Cognitive Styles and Learning Styles. *International Encyclopedia of the Social & Behavioral Sciences*, 1(1), 110-117.
- [13] Sense, A. (2007). Cognitive Style. *Cultivating Learning within Projects*, 4(3), 66-92.
- [14] Maseleno, A., Hardaker, G., Sabani, N., and Suhaili, N., "Data on multicultural education and diagnostic information profiling: Culture, learning styles and creativity," *Data Brief*, vol. 9, pp. 1048-1051, 2016.
- [15] Inglis, J. & Shafer, G. (1978). A Mathematical Theory of Evidence. *Technometrics*, 20(1), 106. doi:10.2307/1268172
- [16] Fioretti, G. (2004). Evidence Theory: A Mathematical Framework For Unpredictable Hypotheses. *Metroeconomica*, 55(4), 345-366. doi:10.1111/j.1467-999x.2004.00197.x
- [17] Kohlas, J. (1995). Mathematical Foundations of Evidence Theory. *Mathematical Models for Handling Partial Knowledge in Artificial Intelligence*, 31-64. doi:10.1007/978-1-4899-1424-8_3
- [18] Dempster, A.P. (1968). A generalization of Bayesian inference. *Journal of Royal Statistical Society. Series B*, 205-247.

- [19] Sabine Graf, Fuhua Lin, Kinshuk, and Rory McGreal (Eds.) (2012). *Intelligent and Adaptive Learning Systems: Technology Enhanced Support for Learners and Teachers*, IGI Global, Hershey, USA.
- [20] Zhang, L., Sternberg, R. J., & Rayner, S. (2012). *Handbook of intellectual styles: Preferences in cognition, learning, and thinking*. New York: Springer Pub. Co.
- [21] Adie, L., Addison, B., & Lingard, B. (2021). Assessment and learning: An in-depth analysis of change in one school's assessment culture. *Oxford Review of Education*, 47(3), 404-422.
- [22] Chen, M. R. A., & Hwang, G. J. (2022). Effects of experiencing authentic contexts on English speaking performances, anxiety and motivation of EFL students with different cognitive styles. *Interactive Learning Environments*, 30(9), 1619-1639.
- [23] Rami, S., Bennani, S., & Idrissi, M. K. (2022). Cognitive Learning Style Detection in e-Learning Environments using Artificial Neural Network. *International Journal of Emerging Technologies in Learning (ijET)*, 17(17), 62-77.
- [24] Dunn, R., & Dunn, K. (1978). *Teaching students through their individual learning styles*. Reston, VA: Reston.
- [25] Dunn, R., & Dunn, K. (1992a). *Teaching elementary student through their individual learning styles*. Boston: Allyn & Bacon.
- [26] Dunn, R., & Dunn, K. (1992b). *Teaching secondary students through their individual learning styles*. Boston: Allyn & Bacon.
- [27] Dunn, R., & Griggs, S. (1998). Learning styles: Link between teaching and learning. In Dunn, R., & Griggs (Eds.), *Learning styles and the nursing profession* (pp. 11-23). New York: NLN Press.
- [28] Messick, S. (2021). Structural relationships across cognition, personality, and style. In *Aptitude, learning, and instruction* (pp. 35-76). Routledge.
- [29] Olmstead, M and Kuhlmeier, V. (2015). *Comparative Cognition*. UK: Cambridge University Press.
- [30] Shettleworth, S. (2010). *Cognition, Evolution and Behaviour*. UK: Oxford University Press.
- [31] Jarvela, S., (2011). *Social and Emotional Aspects of Learning*. Amsterdam: Elsevier.