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Improving Structure of the SLMHM on the Base of the PDCA Cycle

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Abstract

Simple Learning Motivations Hierarchy Model (SLMHM) is a theory that attempts to structure the path of learning "growth" with 16 levels where each next level corresponds to higher aims, motives, results, and satisfaction of needs. The SLMHM has been developed to simplify design, control, and evaluate the learning processes.

The SLMHM was first presented at IES-2020 Conference (Gakh, 2020). More detailed research including analysis of internal structure shows that the model should be corrected. The "Plan-Do-Check-Act" cycle (PDCA Cycle) is popular in management. This paper describes the SLMHM improvements based on analyses of its similarities with the PDCA Cycle. The description of this research makes SLMHM more comprehend.

Introduction

Education is a foundation stone of society. Learning processes in their turn are the main part of education. A good learning motivation model is a tool allowing to solve many problems in education.

The SLMHM was initially developed based on a thought experiment and needed further research and practical proof. The "Plan-Do-Check-Act" cycle (PDCA Cycle) in its turn is well known and was proven in practice. Thus all similarities that exist between the SLMHM and the PDCA Cycle can indirectly confirm the practical value of the SLMHM.

Another issue relates to the internal structure of the SLMHM. A clear and integral internal structure will allow, on the one hand, to have a "beautiful" model. On the other hand, it will allow the development of clearer and holistic processes.

This paper describes analyses of the internal structure of the SLMHM and its similarities with the PDCA Cycle. Improved structure of the SLMHM is also presented.

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Literature, Theoretical Background and Research Questions

(Moen & Norman, 2009) showed that the "Plan-Do-Check-Act" cycle (PDCA Cycle) was born as the result of science evolution started from Galileo Galilei and Francis Bacon (1561-1626). Although the PDCA Cycle relates to management, its originality from the science allows one to analyze its possible similarities with the SLMHM. (Langley, G. Nolan, and K. Nolan elaborated the improvement cycle and called it the PDSA Cycle. The use of the word "Study" instead of the word "Check" emphasizes that the purpose of the third phase is to build new knowledge (Moen & Norman, 2009)). And the word "Act" corresponds to adopting the knowledge that was built at the previous stage. This fact shows the relation of the PDSA Cycle to the learning and endorsed that relationship between the PDSA Cycle and the SLMHM should be analyzed.

Information, as well as Information and Communication Technologies (ICTs), play an increasingly important role in the development of modern society. Modern society forms a new kind of society called "Information Society". In its importance, information can be put on a par with material and financial resources. Today, modern society is a subject of extensive research having holistic and system approaches covering all dimensions of the information society (Ziemba, 2013).

Education is a foundation stone of society. The intensive development of technologies and globalization have led to challenges that require new approaches to solving emerging problems. The phenomena associated with the so-called "Technological Singularity" and the associated accelerated development processes (Eden et al., 2012) require adequate responses from society and education. Education should be flexible enough to satisfy the needs of modern society. At the same time, education should be cheap, available, and of high quality. Achievement of these qualities is not easy although these qualities impact society's future.

Successful learning directly depends on the learners' motivation. Educators can determine through knowledge about students' motivation which students are likely to be involved in and benefit from education. Effective instructional design cannot be completed without the understanding of learners' motivation. According to the research students' motivational beliefs and learning strategies, influence academic outcomes (Clayton et al., 2010).

Deep learning is significantly influenced by the students' intrinsic and extrinsic motivations. The research also shows that a deep learning approach is much more than spending time studying (Everaert et al., 2017). Successful students' learning, learning strategies, and self-regulated learning consistently depend on their motivation (Rashid & Rana, 2019). There are positive and significant relationships between motivation factors and learning strategies. Motivation variables can significantly predict the learning strategies of the students (Hariri et al., 2021). These facts show the importance of motivation in learning processes at different qualitative levels.

To improve learning the educators, first of all, should target motivation. Motivation can be considered as an act or process, stimulus, force, influence, incentive, conditions, or drive (Williams, K. & Williams, C., 2011). The motivation was selected as a key factor of successful learning (Gakh, 2020).

The following research questions should be answered after analyzing possible relations between the SLMHM and the PDCA Cycle:
RQ1: Does the original SLMHM need improvement?
RQ2: Has the SLMHM have similarities with the PDCA Cycle?
RQ3: In what domains the SLMHM can be applied?

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Research Methodology

This research is based on the comparative design (Walliman, 2011) because it finds analogies in the SLMHM and the PDCA Cycle. The descriptive design does also takes place because found findings are described.

According to the abstraction levels (Gakh, 2020; Walliman, 2011), SLMHM is a theory. This paper continues to describe this theory on the conceptual levels. It also attempts to describe indicators, confirming the conceptions. SLMHM can be considered as a 16-level scale where the level number can be classified as a variable value. In this context, the variable can be considered as a motivation level, level of a learning process, level of a scientific breakthrough, and so on. Breaking the complex learning process into several simple processes and studying them can show values that form matrix or tree-like structures. This approach allows deeper considering more variables and modeling.

Findings

The feasibility of this study is concluded in fact that the number of levels in the SLMHM is 16 and the number of steps in the PDCA Cycle is 4. It means that 16 SLMHM can be grouped by 4 and compared with the PDCA steps. The analyses showed that the original SLMHM structure should be improved. Improvements included relocation and renaming of some levels.

In this chapter Improved Structure of the SLMHM, then its structural analyses and comparison with the PDCA Cycle are presented. Comparing of different conceptions, represented by the SLMHM levels and the PDCA steps resulted to get some kind of judgment. Strictly speaking, these judgments cannot give an objective result. But they allow one to more understand the SLMHM model, its relation to the PDCA Cycle, and consequently how to apply SLMHM in practice.

Improved Structure of the SLMHM

Improved Structure of the SLMHM is presented in Table 1.

Table 1. Levels of improved SLMHM structure.

Level	Name	Description
1	Desire	This is the minimal and fundamental motivation. It can be presented as a thought or an idea.
2	Intention	This is the second motivation. However, the previous motivation is also presented on this level. Desire is the fundamental motivation because it can exist without intention. The Intention in its turn cannot exist without desire. Desire can be extrinsic, like all motivations.
3	Feasibility	After having intention, one starts looking for Feasibility to satisfy it. Motivation for looking for Feasibility cannot exist without intention and desire.
4	Action	This motivation level represents a motivation for the physical start of the learning process. Motivations of previous levels should also exist at this level.

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5	Evaluation	The learning process should not take place by itself. It should lead to the results. Thus, the learning process needs evaluation. Evaluation can also include some kind of explicit feedback, but not for all cases. For example, the machine learning component may not require explicit feedback in the case of unsupervised learning.
6	Improvement	The evaluation presented at the previous level should serve to get the highest worth. Evaluation can take place once and does not rely on improving the knowledge (a final exam, for example). At this level, the evaluation should influence the learning process in a way to improve knowledge and skills. There is the motivation to start an iterative, repeating learning process. Supervised machine learning is an example where improvement is required.
7	Alternatives	The learners' skills and personal qualities as well as the situations where the learners' knowledge and skills should be applied are quite different. To have a higher improvement rate (motivation level 6) different alternative learning options should be introduced. These options can include teaching methods, exercises, cases, teachers, and so on. The more learning alternatives are in the learning process the higher the probability of the highest influence (or result) can be achieved. Alternatives also influence several improvement loops (motivation level 6). For the science, it includes considering different cases to test the findings. For AI it equals to size and dispersion of the training set (such variables as diversity index could be used). It can also include the structure of the neural network that contains different alternative sub-structures and the restrictive rules (in the case of the AI amotivation).
8	Innovations	The innovation is the most valuable achievement (result), available at this level (or levels 1-8, because all previous motivations exist at this level). It can be also considered as the level where inventions appear. For AI it is a level where it can produce something that did not exist before.
9	Reward	Innovations must be beneficial. While the assessment presented at level 5 relates to learning processes, at this level there should be an assessment of the innovation itself. In the open letter, Max Tegmark refers to the problem that, due to the high commercial benefit of inventions, they are introduced without proper laboratory research (Tegmark, 2022). Feedback from AI can be helpful (one example was presented by Schmidhuber (2010)).
10	Optimization	To have a higher reward and lower expenditure the learning/research process should be optimized. This optimization can include structuring of resources, team, promises, targets, processes, and so on. This optimization is "internal optimization" that relates to controlled components. Optimization means increasing benefits and reducing harms. For AI it can correspond to software/hardware optimization.
11	Synergy	This level corresponds to the motivation of the teamwork and the cooperation with the partners/customers. It could be considered as a holistic optimization, as an optimization including synergetic methods to achieve a dramatic productivity increase. This level includes "optimization" of interaction between both controlled and uncontrolled components. Principle of emergence appears here. For AI it can include total optimization and change structural/operational conception.

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12	Extraordinaries	At this motivation level conditions to achieve extraordinary inventions appear (satisfaction of all previous levels). The impact of the extraordinary invention is wider and more important than the innovation is. In science, it is a great breakthrough in research. For AI it is a result that can impact the entire humanity.
13	Information	At this level, both the internal and the external information flows become the key motivation. If something extraordinary has been invented/achieved, other people should know about it. It should be presented to all parties for review, evaluation, and implementation. This level contains motivation for different relevant data gathering actions and processing. In the AI world, this level can relate to Big Data.
14	Streamlining	This motivation level is also an optimization of some kind. But this optimization is deeper and wider than level 10. Level 10 optimization mainly relates to the productivity increase. Streamlining mainly relates to internal improvements aimed to improve information processing. The aim here is full control of all informational flows. This level can relate to AI's Data Mining components.
15	Expansion	Streamlining allows handling huge amounts of unstructured information. This ability enables the next ability – to expand. The motivation on this level realizes wishes to cover as many spheres of human life as possible (We will consider expansion from an anthropocentric point of view. So other spheres are also considered if they relate to human interest). An example of expansion motivation is Frederick Taylor's statement about scientific management - "fundamental principles of scientific management are applicable to all kinds of human activities, from our simplest individual acts to the work of our great corporations" (Blake & Moseley, 2011). The appearance of this motivation in AI agents is dangerous for humans because it can lead to unmanaged improvement of AI.
16	Totality	From an anthropocentric point of view, this is the last and greatest level covering all spheres of human life for a long time. It is an unacceptable motivation for AI because if it appears, AI agent starts covering everything available and developing to replace humans.

Structural Analysis

Analysis of the internal structure shows some interesting findings. If place levels in the 4x4 matrix in the way, presented in Table 2, one can see some similarities between levels in rows and columns.

Table 2. SLMHM levels structured to 4x4 matrix.

Rows / Columns	**Column 1**	**Column 2**	**Column 3**	**Column 4**
Row 1	Desire	Evaluation	Reward	Information
Row 2	Intention	Improvement	Optimization	Streamlining
Row 3	Feasibility	Alternatives	Synergy	Expansion
Row 4	Action	Innovations	Extraordinaries	Totality

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The similarities could be as the following:

- Considering the Reward as feedback, the levels in Row 1 show some kind of information. So, the Desire is an idea or thought, that is a piece of information in the mind, the Evaluation is the comparison of information gathered from the Action with the expected values, the Reward is the feedback, and Information does not require an explanation. At the same time, one can say that the levels in Row 1 show some kind of evaluation. In this case, the Desire is an appreciated idea, the Reward is a bonus for evaluated achievement or feedback, and the Information is evaluated or measured given;
- Considering the Intention as a selection of major idea or thought from other thoughts and its strengthening, levels in Row 2 show some kind of improvement or strengthening;
- The levels in Row 3 show some kind of ability. The Alternatives, Synergy, and Expansion can be considered as measures giving the ability. The levels in Row 3 can be also considered as a plurality. Feasibility represents a set of entities allowing to start the learning process. The Alternatives are a set of entities/possibilities to select better options for better learning and improving iterative learning. The Synergy represents parties arranged to have the best results. The Expansion represents a multiplicity of entities to be covered;
- The levels in Row 4 show some kind of result or finish of previous stages. So, the Action is the start of the learning process, the Innovations, and the Extraordinaries represent invention, and the Totality is the highest achievement;
- Each column can be considered as a complete part of a learning cycle. Thus, one can speak about the ability to divide the 16 levels up into 4 stages.

The 4x4 matrix of the SLMHM can be compared to the PDCA cycle. If one juxtaposes the phases of this cycle with the rows of Table 2, the result is the following (see Table 3): the Plan equals to Row 1; the Do equals to Row 2; the Check equals to Row 3; the Act equals to Row 4. At the first look, there is no direct match. But taking into account that the phase Do shows the nature of the process the SLMHM nature is the improvement. It corresponds to the learning process where the latter one equals to learner's improvement. In this case, the phase Plan corresponds to the improvement plan, the phase Check corresponds to the study of Feasibility to improve and build new knowledge about the improvement. (Langley, G. Nolan, and K. Nolan elaborated the improvement cycle and called it the PDSA Cycle. The use of the word "Study" instead of the word "Check" emphasizes that the purpose of the third phase is to build new knowledge (Moen & Norman, 2009)). And the phase Act corresponds to adoption that was built at the previous stage.

Table 3. SLMHM 4x4 matrix aligned to PDSA / PDSA phases.

Phases	**Plan**	**Do**	**Check / Study**	**Act / Adopt**
Plan	Desire	Evaluation	Reward	Information
Do	Intention	Improvement	Optimization	Streamlining
Check / Study	Feasibility	Alternatives	Synergy	Expansion
Act / Adopt	Action	Innovations	Extraordinaries	Totality

Thus, SLMHM complies with the PDCA cycle. It contains 4 types of PDCA cycles according to 4 columns of Table 2. It means that the learning process can be organized cyclically. The learning processes of the 1st level can be modeled with 4 first levels of SLMHM. Such learning processes are aimed to prepare educated people. Improvement of the learning processes supposes including of 8 first SLMHM levels, or two cycles. Such learning processes are aimed to produce innovations. The learning processes using the 12 first SLMHM levels, or 3 cycles are aimed to

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produce extraordinary inventions. And the most advanced learning processes using all 16 SLMHM levels, or all of its cycles can pretend to produce inventions that impact all human activities for a long time (total coverage).

Other interesting findings can be discovered if PDCA cycle phases are juxtaposed with columns of Table 2. In this case, the first SLMHM cycle containing its 4 first levels, forms the phase Plan. There is no explicit conformity between these levels and the planning. But taking into account that SLMHM levels 1, 2, and 3 (the Desire, the Intention, and the Feasibility) are more preparatory levels and only one – the level 4 (the Action) is the start of the real learning process, it can be considered as a planning phase.

Similarly, manner SLMHM levels 5, 6, 7, and 8 can be considered as corresponding to the phase Do. Indeed, all these levels can be improved (the Evaluation gives feedback for the improvement, the Alternatives creates Feasibility, and the Innovations introduces something for improvement of something else). SLMHM levels 9, 10, 11, and 12 can be considered as levels corresponding to the phase Check. These levels are characterized as “improvement of improvement”. It means that the previous phase supposes improvement of the learning process results. But the phase Check supposes improvement of the learning process itself. SLMHM levels 13, 14, 15, and 16 can be considered as levels corresponding to the phase Act. These levels are characterized as adopting knowledge of the learning process that was built at the previous stage.

Discussion and Application

Direct juxtaposing of the SLMHM levels and phases of the PDCA Cycle should be correctly interpreted. Each level of the SLMHM is unique and is qualitatively different from one another. Thus generalization introduces certain distortions. As the result, the SLMHM levels and phases of the PDCA Cycle cannot be compared accurately enough, in the way it can be done for let's say numeric values.

Although the SLMHM is a motivation theory, it can be applied for other conceptions – needs, the satisfaction of needs, processes, technologies, and so on. This study shows that the SLMHM can be used to design processes (at least together with the PDCA Cycle). Application of the SLMHM in different domains is a subject for further research. Issues related to Education, Sustainable Development, and Motivation are of particular interest.

Product in production is something that is appeared during phase Do of the PDCA Cycle. Thus one can say that the phase Do determines the result and the sphere where PDCA Cycle is applied. For the case, presented in Table 3, phase Do relates to some kind of improvement or strengthening (what follows from similarities in Row 2 of Table 2). Thus for this case, one can say that the SLMHM represents a model for some kind of improvement or strengthening process. In case the phase Do is aligned to the Evaluation, Improvement, Alternatives, Innovations (see column Do in Table 3) the main purpose of the SLMHM could be getting an innovation (as the result of phase Do – the Innovations).

The PDCA Cycle represents an iterative process. Levels of the SLMHM can be juxtaposed with the different SLMHM levels in different ways. Table 4 represents an interesting case, starting from checking of existing situation (or studying), acting (or adopting), planning, and doing. Juxtaposing this sequence to the SLMHM levels seems more comprehend.

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Table 4. One of alternative alignment of SLMHM 4x4 matrix to PDSA / PDSA phases.

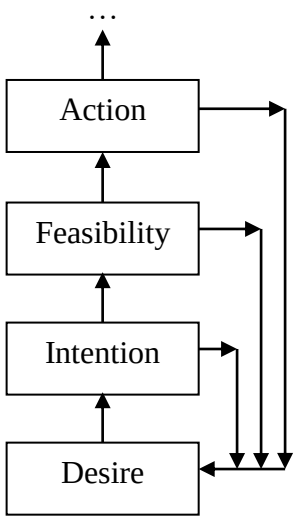
Phases	**Check / Study**	**Act / Adopt**	**Plan**	**Do**
Check / Study	Desire	Evaluation	Reward	Information
Act / Adopt	Intention	Improvement	Optimization	Streamlining
Plan	Feasibility	Alternatives	Synergy	Expansion
Do	Action	Innovations	Extraordinaries	Totality

There are different ways where phases of the PSCA Cycle can be juxtaposed with levels of the SLMHM. At the same time order of the phases and levels does not change. Each way of juxtaposing has its meaning. This fact allows one to consider that the model can be applied in a wide range of real situations.

One can hypothesize that the levels of the SLMHM represent the frequency of relation phenomena. In this way Desire is the most frequent. Not all desires lead to the Intention, thus the Intention is less frequent. Not all intentions lead to looking for Feasibility, thus Feasibility is less frequent. Arguing in this way, one can further conclude that Totality is the rarest level. This picture corresponds also to the sequence of possible cycles (see Picture 1):

- Desire->Intention->Desire->Intention->… ;
- Desire->Intention-> Feasibility-> Desire->Intention-> Feasibility->… ;
- Desire->Intention-> Feasibility->Action-> Desire->Intention-> Feasibility->Action->… ;
- So on.

It is obvious that frequency of phenomena relating to higher levels is less, because all previous levels must have place (in words of motivation - satisfied). Anyway, presence of cycling structures in the SLMHM is an evidence that the model can be applied for iterative processes. This quality of the SLMHM shows that adaptability of designed processes can be increased.



Picture 1. The SLMHM in cycles.

Application of the SLMHM requires an understanding of what can be achieved at the maximum as a goal. In this case, the goal will correspond to the Totality SLMHM level. However, formulating such a goal is difficult for various reasons. First, something can be accidentally ignored. Secondly, an incorrectly formulated goal can become a limitation (there are cases where the benefits of the process exceeded expectations, both quantitatively and qualitatively).

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But the SLMHM allows to correct goals and expectations when developing from lower levels to higher ones. For example, the Alternatives allows supplying additional options/elements that will enrich further levels and make their implementation/satisfaction more possible.

Conclusion

The main value of this research is the improved SLMHM structure. Another value is the description of its relation to the PDCA Cycle. Summary of this relation can be presented as:

- The structure of improved SLMHM is more clear and integral in comparing to the initial version;
- SLMHM can be applied for iterative processes;
- SLMHM can be applied for cases where goals are not formulated well;
- SLMHM can be used in a wide range of domains.

Improved SLMHM is more deeply justified in this research in comparing to the original SLMHM. This paper does not discuss differences, rather it justifies the improved structure presented in Table 1. Since the original SLMHM structure was created based on a thought experiment, it is less substantiated. Improved SLMHM structure should be used in future works.

Improved SLMHM structure is considered compliant with the PDCA Cycle. Thus one can claim that SLMHM can be applied in these domains, where PDCA Cycle can. At the same time, this application should be studied and described for each case.

Limitations and Recommendations

Although the SLMHM is improved, it remains a theory. Moreover, some statements of the SLMHM are hypotheses. So, further research and practical proof of the SLMHM are necessary. At the same time, the model can be used in a wide range of applications. The most interesting cases, where the application of the SLMHM should be studied include, but are not limited by:

- **Education**. Application of the SLMHM with prioritizing of the adaptability;
- **Smart City**. Application of the SLMHM because there is no definition of what Smart City is, and consequently there are no defined goals;
- **Sustainable Development**. Use of the SLMHM to evaluate development level and plan the growth;
- **Artificial Intelligence**. Use of the SLMHM for study, analyses, motivation, and control.

SLMHM has been developed through a thought experiment. Thus, the model is subjective because it is based on though limitations of the researcher. One can say that this limitation simplifies the actual situation. Thus the model can be considered as one providing the ability to simplify complex processes and analyze them in a structured manner.
SLMHM does not provide information on how to motivate and how to achieve satisfaction. But it can be used to analyze the problems associated with motivation and satisfaction and understand what kind of motivation is needed to achieve a higher quality level in the learning process.

References

Gakh, D. (2020). A review of the simple learning motivations hierarchy model. Proceedings of the XII International Scientific-Practical Conference: Internet-Education-Science 2020, 225-227.

Blake, A. M., & Moseley, J. (2011). Frederick Winslow Taylor: One Hundred Years of Managerial Insight. The International Journal of Management, 28 (4/2), 346-253.

Clayton, K., Blumberg, F., & Auld, D. (2010). The relationship between motivation, learning strategies and choice of environment whether traditional or including an online component. British Journal of Educational Technology, 41(3), 349–364. https://doi.org/10.1111/j.1467-8535.2009.00993.x

Eden A. H., Steinhart E., Pearce D., & Moor J.H. (2012) Singularity Hypotheses: An Overview. Singularity Hypotheses. The Frontiers Collection. https://doi.org/10.1007/978-3-642-32560-1_1

Everaert, P., Opdecam, E., & Maussen, S. (2017). The Relationship between Motivation, Learning Approaches, Academic Performance and Time Spent. Accounting Education, 26(1), 78-107. https://doi.org/10.1080/09639284.2016.1274911

Hariri, H., Karwan, D. H., Haenilah, E. Y., Rini, R., & Suparman, U. (2021). Motivation And Learning Strategies: Student Motivation Affects Student Learning Strategies. European Journal of Educational Research, 10(1), 39-49. https://doi.org/10.12973/eu-jer.10.1.39

Moen, R., & Norman, C. (2009). Evolution of the PDCA cycle. Asian Network for Quality Conference.

Rashid, S., & Rana, R. A. (2019). Relationship between the Levels of Motivation and Learning Strategies of Prospective Teachers at Higher Education Level. Bulletin of Education and Research, 41(1), 57-66.

Schmidhuber, J. (2010). Formal Theory of Creativity, Fun, and Intrinsic Motivation. IEEE Transactions on Autonomous Mental Development, 2(3), 230-247. https://doi.org/10.1109/TAMD.2010.2056368

Tegmark, M. (2022). An open letter: research priorities for robust and beneficial artificial intelligence. https://futureoflife.org/ai-open-letter. Accessed 31 Feb, 2022

Walliman, N. (2011). Research methods. The basics. Routledge.

Williams, K. C., & Williams, C. C. (2011). Five key ingredients for improving student motivation. Research in Higher Education Journal, 121-123.

Ziemba, E. (2013). The Holistic and Systems Approach to the Sustainable Information Society. Journal of Computer Information Systems, 54(1), 106-116. https://doi.org/10.1080/08874417.2013.11645676