

Sustainable Learning: Implications from the Law of the Minimum

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Abstract

Learning is said to be sustainable when it is transferable or finds application in real life. Such learning takes on a balanced approach following the *Law of the Minimum*, a principle that Liebig developed. Used primarily in agriculture, this principle gives importance to finding the scarcest ingredient for the overall growth of plants. Just as an abundance in the rest of the ingredients hardly make a difference if an essential ingredient is scarce, learning is influenced by human factors, including specific scarce components such as learner readiness, teaching methods, and learner motivation. A balanced approach to learning yields True education, which holistically caters to the body, mind, and soul and is sustainable. Seven suggestions are given to enhance sustainable learning that results in life-long learning.

Keywords: *sustainable learning, readiness to learn, Law of the minimum, limiting factor, inner curriculum, human factors*

Introduction

Learning is an incredible natural activity. Humans are equipped with an inherent ability and interest to learn. This fascinating activity takes place from the time (or even before) we are born, and it continues till the end of one's life. Learning not only helps us survive but also helps generate new knowledge. The cumulative knowledge during the past centuries has resulted in the massive knowledge base of the 21st century.

Learning takes place mainly in a social setting with the support of significant others such as parents, teachers, peers, and using books and various media. While all learning is meant to be sustainable, it is often not. Learning that consists solely of memorizing facts cannot be sustained because most of what is learned is quickly forgotten. On the other hand, learning that transfers or finds application in real-life situations impacts the present and the learners' future. Sustainable learning calls for a more balanced approach. The *Law of the Minimum*, a principle from agriculture, serves as a model to appreciate the significance of this balance that results in sustainable learning.

Sustainable Learning

Sustainable and sustainability are becoming buzzwords in our workplaces or other professional circles. Sustainable reform and sustainable development are themes that direct us to rethink our current practices to improve upon them. The intention is a better future for all concerned. As educators, we may translate this concept of sustainability into our profession by considering facilitating 'sustainable learning.' But what does sustainable learning entail? How is it practiced? These questions are important to consider.

Sustainable learning may be defined in more than one way. One definition of sustainable learning is that it is learning that continues throughout life. Sustainable learning is possible when learning becomes a lifestyle of the individual. Some may call it 'lifelong learning,' a term popularized by Edgar Faure more than three decades ago. Sustainable learning cannot be just confined to schools and other educational institutions. Such learning happens in all kinds of life situations and continuously. The main attribute of the learner who is engaging in lifelong learning is possessing an attitude of learning. Thus, the responsibility for sustainable learning rests with the individual learner. Knapper, who supports the idea, states, "The underlying precept of lifelong learning is that learning is too important to be left to schools and universities and that the responsibility for learning throughout life and from life lies with the individuals" (Knapper, 2006).

Another aspect of sustainable learning is that its outcomes meet both the present and future needs of an individual. Meeting these demands is determined by the type of learning in which the learner participates. Ideally, it calls for a well-balanced education or True education, as it is also called. Ellen G. White mentions that "harmonious development of the physical, the mental, and the spiritual abilities" manifests true education (White, 1995).

A balanced education seeks to promote the three main domains of life—physical, mental, and spiritual (see Figure 1). As the Bible mentions, our very best model of a well-lived life—Jesus — is said to have "increased in wisdom and stature, and in favor with God and man" (Luke 2:52). This verse points to the balanced learning outcome and encourages us to design learning experiences that bring about such results. Neglecting one of these areas would diminish the overall effectiveness of growth and learning, making learning unsustainable; such learning does not adequately meet the learner's needs now or in the future, directly and indirectly.

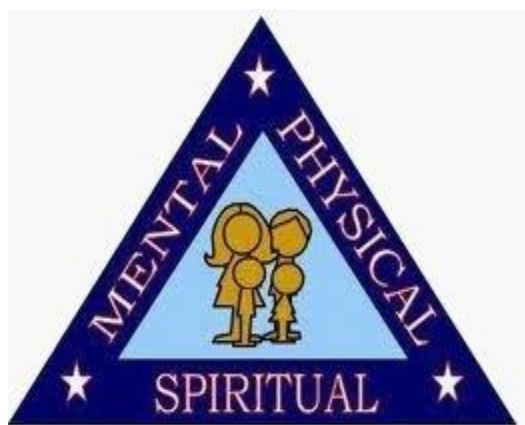


Figure 1. Balanced education.

Thus, when we think of sustainable learning, it becomes imperative that a balance among the different aspects of life needs be maintained. Neglecting one area alone would diminish the cumulative result of an individual's learning, impacting its sustainability adversely. For example, neglecting one's physical needs to enhance mental growth will jeopardize the individual's overall well-being. Spending unusually long periods of time a day in exercises and keep-fit activities at the expense of spiritual growth activities cannot bring that balance, too. An individual's overall growth and learning appear to be determined by the domain that receives the least attention. The Law of the Minimum is a fine analogy that comes in handy in understanding this balance issue. The following section introduces

this intriguing principle.

The Law of the Minimum

Carl Sprengel devised the Law of the Minimum in 1828, and it is a well-known principle in agricultural research. It was popularized by Justus von Liebig, a German chemist, and eventually known as Liebig's Law.

Plant output is proportional to the most inadequate plant nutrient, according to the Law of the Minimum. In other words, the growth of plants is controlled by the scarcest resource, and even if the other essential nutrients are adequate or even abundant, the overall growth of the plant will be limited due to the lack of one essential ingredient (Gorban et al., 2019).

Liebig uses an interesting comparison and likens the potential of a crop to a wooden barrel with staves/boards of unequal length (see Figure 1). The length of the shortest stave limits this barrel's capacity, which can only be increased by lengthening that stave. Similarly, the growth of plants is controlled by the least available growth factor (for example, nitrogen, phosphorus, water, and light). When this factor is depleted, the growth of the plant is limited. On the other hand, increasing the amount of this "limiting factor" will improve the growth of the plants—the Law of the Minimum points to lessons that can be applied in multiple situations, including learning.

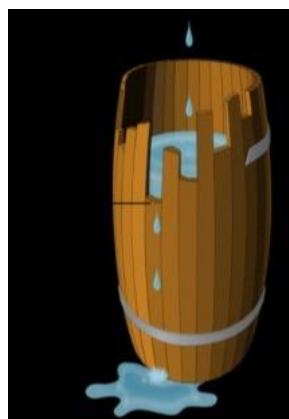


Figure 2. Liebig's barrel.

The Connection

It is evident that many ordinary real-life situations connect to the Law of the Minimum. Most often, the scarcest essential element, indeed, determines our progress. For example, if one does not have the required amount of baking powder, the baking cannot be continued until this essential ingredient is found. Another example of the Law of the Minimum is found in the global economy. It is generally agreed that oil is one of the substantial limiting factors in the economy. When oil supply is reduced, the economy seems to shrink, as seen in the 2008-2009 recession. Another applicability of this law is seen in terms of the least plentiful element limiting the health and growth of individuals.

For instance, infant formula lacks certain essential nutrients (limiting factors) that breast milk provides. Though the formula may have an abundance of other nutrients, its overall effectiveness is limited by the missing "limiting" ingredients. Take yet another example from health: the lack of one aspect in one's physical needs such as proper diet, exercise, or rest

can limit the individual's general well-being. Countless such examples from life relate to the Law of the Minimum.

There are also important implications of the Law of the Minimum to learning. We can consider the main lesson that weaknesses (limiting factors) usually determine the actual yield potential or learning. These impediments must be identified and handled, just as strengths must be maintained and appreciated. In the final analysis, sustainable learning depends upon how we deal with the limiting factors. What are the limiting factors in learning? Are there any *critically* important limiting factors in learning? These questions can be addressed with the Law of the Minimum approach.

The Limiting Factors in Learning

Any limiting factor within a system is the least available essential element, determining the overall outcome. Several essential elements need to be balanced for learning to be optimal in a learning system. Some of these elements may be identified as prerequisite knowledge and skills, attitudes and perceptions, motivation, the physical condition of the learner, facilities in the classroom, language fluency, cognitive ability, classroom management, books and other media, teaching methods, integration of faith and learning, assessment practices, and support of significant others such as teachers, parents, and peers.

The factors that influence learning may be broadly categorized into two: human and non-human. Even if one were to make a complete list of the known factors that influence learning, it is evident that the items making up the human factor outweigh both in number and significance. The human aspect is, without question, the most important factor in a learning environment—no learning can occur without a learner and a facilitator. Even in the presence of an abundance of other factors such as facilities and learning materials, human factors such as readiness, human support, teaching method, and motivation make the most difference in learning. Taking the human factor as the limiting variable, let us address this factor within a learning environment—whether formal or informal. We want to see a balanced education that results in sustainable learning, which meets the needs of learners today and in the future.

Take one example—learner readiness—as a critical human factor for learning. If we redefine “yield” as learning and “the most limiting nutrient” as learner ready, we may conclude that learning is directly proportional to learner readiness, according to Ozden (Ozden, 2011). However, merely increasing any elements of the learning system's nonliving constituents (for example, instructional materials, methods, and environment) may not improve learning effectiveness. Readiness to learn is thus a critical aspect of learning. Similar explanations related to the Law of the Minimum are possible concerning other human factors that need to be balanced. All in all, Liebig's Law of the Minimum can provide insights into how sustainable learning occurs. Based on this premise, weaknesses (limiting factors) typically determine the actual outcome.

Learning can be a pleasurable activity even if we exclude the economic ramifications and other related benefits. However, it is tough to find time to learn anything unnecessary for an increasingly hectic environment. What is learned is essential, perhaps to pass an exam or complete a grade/course/program, and everything outside is considered trivial. However, lasting or sustainable learning has purposes beyond these so-called essentials and involves the development of the whole person. How can we make learning a lifestyle resulting in sustainable learning?

Enhancing Sustainable Learning

Considering that the human constituents are the limiting factors in learning, these constituents can make a difference in producing sustainable learning. Here are seven suggestions that promote sustainable learning, and these suggestions have implications in the way we learn and the way we teach.

1. Learn How to Learn

One of the drawbacks of traditional or formal learning is that we tend to concentrate more on *what* we are learning instead of *how* we are learning. The information surge of our times is so rapid that much of what is learned today becomes obsolete in a few years. Equipping ourselves with learning skills will allow us to continue to learn in the future. This “learning to learn” process or metacognition considers one’s learning style, past learning experiences, and motivation to learn.

Taking the responsibility to learn on oneself is an essential premise of metacognition. One practical suggestion (Learning to Learn, 2012) for learning that uses metacognition is using these four steps: (a) Begin with the Past; (b) Proceed to the present; (c) Consider the Process; and (d) Build in Review. During the first step, beginning with the Past, the learner answers questions such as “What types of activities did you use for learning in the past: reading, memorizing, asking questions, studying alone or with others?” “Which ones did you enjoy?” “Which ones would you avoid?” In the second step of Proceeding to the Present, the questions that guide the learner were: “How interested am I in the topic?” “How much time do I have for this?” “What are the barriers, and what can I control?” The third step of considering the process allows checking the following questions: “What do I already know about this?” “What resources do I need?” “Am I understanding what I learned?” “Who or what can help me learn better?” In the fourth and final step of Build in Review, the learner asks questions such as “What did I do well?” “What can I improve next time?” “Did I use the right conditions?” “Was I disciplined enough during the learning time?”

Effective learning incorporates reflection on the process of learning. Reflective discussions are based on this belief: The student usually knows more than the teacher about what he has learned—even if he knows less about what was taught. Such reflective thought processes must become habitual. Teachers can encourage discussions that make reflective thinking more transparent in classroom learning. Such dialogues allow merging the personal aspects of learning experiences and the shared language that facilitates learning.

Take the example of a teaching strategy of Jerome Bruner called the Concept Attainment helpful in teaching a new concept. The three phases of this strategy (Siddiqui, 2013) are (a) Presentation (the teacher shows examples of a concept), (b) Testing (students form hypotheses about the concept till they get the concept), and (c) Analysis of Thinking (students talk about their thinking process). The third and final phase of the strategy asks students to think aloud their thinking processes regarding what confused them and what helped them get the right concept. Talking about learning is powerful and needs to become a habit for learners, and teachers can encourage such dialogues on reflective thinking.

2. Develop a “Helicopter” Vision

Usually used in business sectors, the “helicopter” vision refers to the ability to see the broader picture of a situation. Generally, situations we find ourselves in are multifaceted and require skills from different areas of expertise. Learn information and skills you can use for various life situations. Learning speedreading, for example, helps to browse through a great

deal of reading materials in time-saving ways. This skill is advantageous for a student, teacher, pastor, or businessperson. Meeting a situation that uses such efforts can be a source of pride. Seeing the value of learning a specific content or skill voluntarily in advance is the spirit of a visionary. Thus, sustainable learning includes integrating knowledge and skills from different disciplines.

3. Make Reading a Habit

Wide reading opens the mind to myriad ideas and is one of the best ways to learn. As Joseph Addison mentions, “reading is to the mind what exercise is to the body” (Akinpelu, 2008). Reading activates the mind and promotes learning. You should always have a book that you are reading, and you should have this book with you at all times. You should be able to read this book when you have the time. You should always have a book that you are reading, and you should have this book with you at all times. You should be able to read this book when you have the time. Taking a few minutes between work throughout the day might result in reading one book every week. This works out to at least 50 books every year. Some books may take longer to read than others but keep reading whether it takes a year or a week. Similarly, the reading habit can be practiced in digital books and libraries in the contemporary world. You will find positive effects of reading in your conversations—you have ideas to share and appreciate; your formal learning and teaching materials seem to make connections in one way or the other to what you read; and your attitude towards learning itself improves—you are excited about learning and make time for it instead of using time on the usual frivolous activities.

Related to reading is meditative reading, especially at the beginning of the day. The early time of the day is generally considered optimal for learning. The amount of time you spend reading may be varied. The best use of this time is for personal devotion and study of God’s word. Balancing the spiritual aspect of life is also essential, for sustainable learning is all about balancing the essential factors of life.

4. Keep a “To-Learn” List

Many of us use “to-do” lists. These are lists of tasks that we must accomplish daily. In addition to this list, make a “to-learn” list. It can be used to scribble down ideas for new research topics (Shepard, 2007). Perhaps you would want to learn a new language, swim, or read Shakespeare or Ellen G. White’s writings.

Write down whatever motivates you. Look for opportunities to learn what you had in mind. Just as ticking off items in the “to-do” list brings much satisfaction at the end of the day, an occasional ticking off an item from the “to-learn” list brings immense satisfaction.

Another suggestion is to begin an adventurous project. Set out to do something “larger than you” that you do not know precisely how. This type of forced learning may be both pleasurable and demanding. If you have not tried writing an article for publication yet, try it on your favorite topic and send it to the publisher. Consider developing a desire for learning computers if you do not know anything about them. Try painting if you think you are a terrible artist. The idea here is that the project must be challenging enough that the experiences of frustrations and problem solving can contribute much to learning.

5. Have Some Intellectual Friends

Friends are suitable for different situations. So, you have different kinds of friends. Make friends also who talk about ideas. These are people who think and make you think. These are intelligent people who invest much of their time learning new ideas and skills. David B.

Shepard mentions, “their habits will rub off on you. Even better, they will probably share some of their knowledge with you” (Shepard, 2007).

6. Learn Collaboratively

Learning in real life happens mainly in a social setting—with other people, directly or indirectly. In other words, learning need not mean being trapped with a stack of books. There are many other ways to learn. Join groups or organizations that teach skills. Because of the supportive learning environment, workshops and group learning events can make learning more transferrable. Learning ought to be a pleasant, if not fun, social experience. Teachers who use Cooperative Learning in their classes often see the impact of this suggestion.

7. Teach Others

The Latin expression *docendo discimus* (we learn by teaching) is correct. Teaching undoubtedly is one of the most effective methods to learn. If you can articulate your ideas to others, you are more likely to recall what you have learned. Start a blog, write an article, agree to a public speaking engagement, hold a seminar, mentor someone or simply talk about your thoughts with a friend. You will increase your self-confidence and feel more useful too. Try this experiment: Select an unfamiliar and rather complex topic and learn about it for a while. Now, try to teach/share what you learned with a friend/spouse. By the end of your sharing, you will discover that you understand the concept far better than you did at the start.

The above suggestions are only a beginning list. Choose other options that work for you. The desire for sustainable or lifelong learning does not come naturally. You cannot always rely on other influences to persuade you to study. The desire must derive within. This desire results in the *Inner Curriculum* that Brubaker (2004) mentions. The inner curriculum consists of learning experiences that you plan and initiate because of your interest. The result also will be the “passion of the Explorer” (Barnett, 2014, para. 5) with the three dispositions: (a) Commitment to Domain, (b) Questing, and (c) Connecting. These dispositions will cause you to have a lasting positive impact in your workplace, drive you to look for challenges that contribute to improved performance, and make you pursue deep, trust-based interactions with others through growth experiences, respectively. It is up to you to make lifelong learning a priority in your life after you have decided to make it a habit. The common thread that runs in these suggestions is simply that you, the human constituent, are the most crucial component of sustainable learning.

Conclusion

Learning is a wonderful activity, and most humans have an innate desire to learn. It broadens our perspective and provides us with new information that we may apply to improve our lives. Taking charge of one’s own learning is an essential aspect of sustainable learning. According to the Law of the Minimum, it is reasonable to conclude that the quality of learning is directly proportionate to the limiting aspects of learning, particularly those related to the human variables mentioned above. No matter how high the quality, non-living constituents (materials, methods) have only secondary effects on this process. Therefore, the challenge for learners, whether young or old, is to look at learning in a new way, with an open mind, and with the option to receive and give. Perfectly reflecting today’s sustainable learning demands, Alvin Toffler mentions, “The illiterate of the twenty-first century will not be those who cannot read and write, but those who cannot learn, unlearn and relearn” (Hennessy, 2002). Let such sustainable learning be our passion.

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