Pattern Language and the Future of Education in Light of Constructivist Learning Theories, Part 4

Constructionism of Seymour Papert

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ABSTRACT

The study discusses how pattern language contributes to the formation of knowledge and creation based on constructivism learning theory. From the point of view of constructivism, humans construct knowledge internally and cannot acquire it from external inputs. Building on this viewpoint, the study aims to elucidate pattern language and how it supports learning and practice. The study focuses on constructionism as proposed and discussed by Seymour Papert and his successor, Mitchel Resnick. Furthermore, it clarifies how pattern language supports learning by making, debugging, and collaborating. In this manner, pattern language can be viewed as a useful and creative tool for the future of education.

CCS CONCEPTS

[Social and professional]: Professional topics—*Informal education; K-12 education; Adult education*

KEYWORDS

learning, Constructionism, Constructivism, pattern language, design patterns

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1 Introduction

Pattern language is a language that verbalizes the rules of thumb for creative acts and supports individuals in acquiring such acts in high quality. In this respect, how, then, can knowledge and improvement be achieved? The study focuses on how pattern language supports learning and practice from the viewpoint of constructionism, as proposed by Seymour Papert. Note that this study is part of a series of four papers, which aims to determine the role of pattern language through the learning theory of constructivism.

Considering pattern language and how it can affect individuals, its relation to practice and learning should be firstly examined. A difference between knowing as information and learning from experience exists. Therefore, the study focuses on the viewpoint that one cannot develop oneself by knowing the contents of sentences written in a pattern. From the perspective of constructivism, knowledge can be constructed within one's experience instead of importing descripted knowledge from the outside. Based on this understanding, pattern language can be considered a medium that encourages and supports practices and learning from experience in contrast to inputting descripted knowledge from others.

Constructivist learning theories, which were originally purported by Jean Piaget, emphasize that knowledge is constructed within individuals (Piaget, 1971, 1973), as our previous paper (Iba and Munakata, 2019) introduced. The current study takes up Seymour Papert (1928–2016) who partly follows Piaget's theory and emphasizes *learning by making*. Papert studied under Piaget for 5 years and developed a school of thought in the MIT Media Lab through the research and development of tools for thinking and the effects of such tools on the learning process of children. In the following sections, we first introduce the conception proposed by Papert and discuss how we can reconsider pattern language from his perspective.

2 Constructionism by Seymour Papert

In the preface of his book, *Mindstorms: Children, Computers, and Powerful Ideas*, Papert (1993a) looked back to an episode in his childhood and recalled playing with gear toys out of keen interest in cars at an early age. As a result, he came to understand the mechanics of combining and rotating gears on an abstract level and grasped mathematical functions by calculating the systems and mentally arranging the gears. From this experience, Papert became inspired to verify his idea in terms of the fundamental facts of learning.

> "Anything is easy if you can assimilate it to your collection of models. If you can't, anything can be painfully difficult." (Papert, 1993a, p. xix)

In this remark, the word "assimilate" is used, which Piaget uses to explain the recognition and construction of knowledge. Notably, *assimilation* is the application of appropriate *schéma* to represent a perceived situation (Fig 1). Piaget stated that humans only assimilate things that are assimilable to the cognitive structures they presently possess. In other words, things that cannot be assimilated cannot be recognized and are thus overlooked.

Although Papert is a successor to Piaget, he has made further developments in Piaget's thoughts. The route to the development is integrated in the following question:

> "*The understanding of learning must be genetic*. It must refer to the genesis of knowledge. What an individual can learn, and how he learns it, depends on what models he has available. This raises, recursively, the question of how he learned these models." (Papert, 1993a, p. xix)

Truly, assimilation to structure is required to enable the subject to undergo cognition and understanding. However, he wondered how such a structure is made. The answer by Piaget was by experiences that one has so far. Although Papert agreed, he pursued that point further and focused on tools that contribute to the construction of the structure.

Remember that Seymour as a boy constructed a mathematical structure by learning and operating gears. Although Piaget studied the relationships of objects in the immediate environment, such as rocks and trees, blanket basically, Papert was more interested in advanced devices and tools that can be composed and made by learners (Fig. 2). Thus, he developed a programming environment named "LOGO," where users can write a program that directs a turtle's movement and draw a trajectory as graphics. This LOGO environment is a tool for thinking.

He named his proposition as "constructionism" to emphasize the significance of the activity of construction for learning. The term "constructionism" is built on the term "constructivism," which was coined by Jean Piaget. In contrast, however, constructionism emphasizes "construction" (Papert, 1993b) and indicates its position against "instructionism" (Papert, 1993c), which pertains to education by instruction according to conventional education.

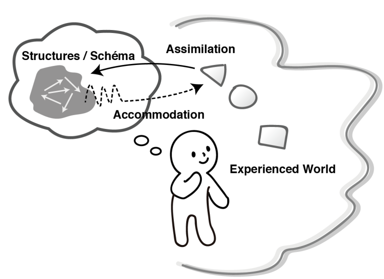

Figure 1: Recognition is constructed by "assimilation" and "accommodation" of cognitive structures (Iba & Munakata, 2019)

Figure 2: Learning by construction

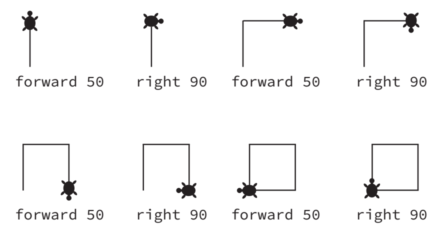

Figure 3: Commands for the turtle's movement on LOGO (LOGO Foundation, created from 2000)

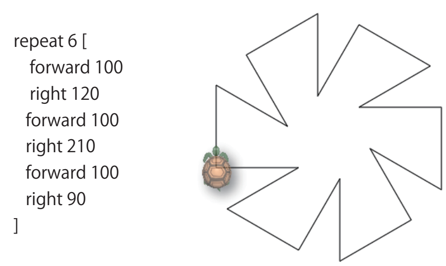

Figure 4: Sample of a program in LOGO (left: program code written by Takashi Iba; right: trajectory of the turtle[1])

In the LOGO environment, children write programs and give instructions for the action of a virtual turtle in a computer world (Figs. 3 and 4). As such, Papert said, "the child programs the computer. And in teaching the computer how to think, children embark on an exploration about how they themselves think" (Papert, 1993a, p. 19). In this process, children think and understand deeply. Papert describes this notion as follows:

> "Even the simplest Turtle work can open new opportunities for sharpening one's thinking about thinking: Programming the Turtle starts by making one reflect on how one does oneself what one would like the Turtle to do. Thus teaching the Turtle to act or to 'think' can lead one to reflect on one's own actions and thinking. And as children move on, they program the computer to make more complex decisions and find

[1] This graphics is generated by running the program on ACSLogo For Mac OS X (https://www.alancsmith.co.uk/logo/).

> themselves engaged in reflecting on more complex aspects of their own thinking." (Papert, 1993a, p. 28)

Next, we introduce "debugging" during learning by making, which Papert stated as one of the important skills in programming and learning. "Debugging" is a term in the computer field, which means "removing a bug." In this context, "bug" is a glitch hiding in the program, which causes the computer to misbehave. Papert emphasized that debugging is very important for learning and programming.

> "But when you learn to program a computer, you almost never get it right the first time. Learning to be a master programmer is learning to become highly skilled at isolating and correcting 'bugs,' the parts that keep the program from working. The question to ask about the program is not whether it is right or wrong, but if it is fixable. If this way of looking at intellectual products were generalized to how the larger culture thinks about knowledge and its acquisition, we all might be less intimidated by our fears of 'being wrong.' This potential influence of the computer on changing our notion of a black and white version of our successes and failures is an example of using the computer as an 'object-to-think-with.'" (Papert, 1993a, p. 23)

The entire process of finding, solving, and improving a problem is valued in the LOGO environment as learning by making. Although debugging is a term mostly used in the field of computers, Papert argued that the fundamental concept of this notion is that "Surely 'debugging' strategies were developed by successful learners long before computers existed" (Papert, 1993a, p. 23). Individuals frequently undergo problem identification and solving, repairing, and improving not only in programming but also in everyday life. Seemingly, the topic of debugging brings to light the problem of today's education and a new direction that the field should follow.

> "One does not expect anything to work at the first try. One does not judge by standards like 'right — you get a good grade' and 'wrong — you get a bad grade.' Rather one asks the question: 'How can I fix it?' and to fix it one has first to understand what happened in its own terms. Only then can we make it happen on our terms." (Papert, 1993a, pp. 101–102)

Are schools in our society presently able to become such a place? On the one hand, schools and educators claim that they will focus on "trial and error." On the other hand, is providing a correct answer at the first time required? Should students be given opportunities to correct their mistakes and improve the quality of their answers? Papert illuminated the problem of modern education with the following episode:

> "I have seen this in many children's first sessions in a LOGO environment. The child plans to make the Turtle draw a certain figure, such as a house or stick man. A program is quickly written and tried. It doesn't work. Instead of being debugged, it is erased. Sometimes the whole project is abandoned. Sometimes the child tries again and again and again with admirable persistence but always starting from scratch in an apparent attempt to do the thing 'correctly' in one shot. The child might fail or might succeed in making the computer draw the picture. But this child has not yet succeeded in acquiring the strategy of debugging." (Papert, 1993a, pp. 113–114)

> "The ethic of school has rubbed off too well. What we see as a good program with a small bug, the child sees as 'wrong,' 'bad,' 'a mistake.' School teaches that errors are bad; the last thing one wants to do is to pore over them, dwell on them, or think about them. The child is glad to take advantage of the computer's ability to erase it all without any trace for anyone to see. The debugging philosophy suggests an opposite attitude. Errors benefit us because they lead us to study what happened, to understand what went wrong, and, through understanding, to fix it. Experience with computer programming leads children more effectively than any other activity to 'believe in' debugging." (Papert, 1993a, p. 114)

Imagining the circumstances that everyday school life brought to students, debugging can pave a new approach for the present situation of schools. In addition, in learning by making based on constructionism, learning arts becomes important because it enables individuals to actually create an object. "As in a good art class, the child is learning technical knowledge as a *means* to get to a creative and personally defined end" (Papert, 1993a, p. 134). Furthermore, repairing is an important process in creating objects with wholeness.

> "In the commonplace use of the word repair, we assume that when we repair something, we are essentially trying to get it back to its original state. This kind of repair is patching, conservative, static. But in this new use of the word repair, we assume, instead, that every entity is changing constantly: and that at every moment we use the defects of the present state as the starting point for the definition of the new state." (Alexander, 1979, p. 485)

In addition, learning based on constructionism enables individuals to create an object by collaborating with others. If a new object is actually made for the first time in that place, collaboration can extend beyond the experience and levels of knowledge. Papert noted that such an action enables students to collaborate even with teachers.

> "In traditional schoolrooms, teachers do try to work collaboratively with children, but usually the material itself does not spontaneously generate research problems. Can an adult and a child genuinely collaborate on elementary school arithmetic? A very important feature of work with computers is that the teacher and the learner can be engaged in a real intellectual collaboration; together they can try to get the computer to do this or that and understand what it actually does. New situations that neither teacher nor

> learner has been before come up frequently and so the teacher does not have to pretend not to know. Sharing the problem and the experience of solving it allows a child to learn from an adult not 'by doing what teacher says' but 'by doing what teacher does.'" (Papert, 1993a, p. 115)

In this manner, the situation in which "the teacher as well as the child can be genuinely excited by it" (Papert, 1993a, p. 134) is achieved, which is for *making*, not because it is about using computer. A project of creating enables teachers to learn by working in partnership with students.

3 Extensions by Mitchel Resnick

This section provides an overview about the extended cases of constructionism by Mitchel Resnick, who collaborated with Papert at the MIT Media Lab (Kafai and Resnick, 1996; Resnick, 2017). Resnick developed the programming environment "Scratch" and established an online community for it. When Papert made LOGO 50 years ago, only computers that were relatively larger machines than the modern personal computers were invented. At the time, LOGO was extremely advanced. To date, however, LOGO is considered very simple and old-fashioned because of the variety of media environments currently available. In contrast, Scratch is a colorful and visual programming environment that easily attracts children's attention.

However, the most important point in Resnick's development is the establishment of an online community where individual users can share and interact with their outcomes. In this online community, learning from and collaborating with others become possible. Resnick introduced several episodes about how children experience and have fun in this online community in his book *Lifelong Kindergarten* (Resnick, 2017). Users can also obtain players who watch and play with their resources and deliberate on a product that is enjoyable and pleasant for all users.

The LOGO environment supplies tools that focused on interaction between a maker and an object, whereas Scratch is socially extensive and supplies a platform where users can interact with and learn from one another. In this platform, collaboration can occur beyond geographical limitations. In addition, working on creative activities alone is not tantamount to loneliness because in an online community, users sense the company of others with similar interests.

Moreover, Resnick focused on constructionism as proposed by Papert along with the learning style of Kindergarten as proposed by Friedrich Froebel, which became known worldwide in the nineteenth century. Resnick positively considered the learning style of Kindergarten because students of all ages can learn through this method. Therefore, he named his project at the MIT Media Lab "Lifelong Kindergarten" and published a book with the same title (Resnick, 2017). Resnick focused on "Froebel's gifts" and positioned them as a source of learning by "making" objects.

> "Froebel wanted his kindergarten children to gain a better understanding of the world around them. One of the best ways to do that, he realized, was for children to create models of the world — to 're-create' the world through their own eyes, with their own hands. That was the ultimate goal of Froebel's Gifts: understanding through 're-creation.'" (Resnick, 2017, p. 8)

In addition, Resnick supported "recreation" and "re-creation" and stated that "Kindergarten children are most likely to create and build when they are engaged in playful, imaginative activities" (Resnick, 2017, p. 8) to pinpoint a creative learner. Resnick illustrated the activity process in Kindergarten as a "creative learning spiral" (Fig. 5).

The first step is "imagine," where a child begins by imagining an ideal world. The second step is "create"; this enables the transformation of ideas into form. The third step is "play," where the child experiences play. In this step, the child frequently realizes that a product should be improved. Then, the child can "share" ideas with others and thus obtain their participation and ideas. Afterward, the child will "reflect" on the products and aspects that require additional improvement. Furthermore, based on experience, the child begins a new cycle using the same steps. By repeating the creative learning spiral, the power of creative thinking is enhanced. Resnick highlighted that project-based learning based on the creative learning spiral should be carried out and is important not only for children at Kindergarten but also for adults, including researchers at the MIT Media Lab.

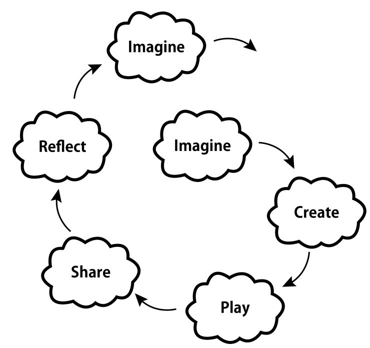

Figure 5: Creative learning spiral (Resnick, 2017)

Moreover, Resnick proposed the "four Ps of creative learning," namely, "project," "passion," "peers," and "play," as the fundamental principles for becoming a creative thinker through learning experiences. The first P pertains to the launching of a "project." In the Scratch environment, a "project" unit is established for goal setting. In a project, individuals can work alone, with others, or with other members of the online community. The second P denotes working on the project with passion. In other words, working on a project where passion lies is important because of the various themes and styles of a project. The third P points to the existence of peers. Peers are necessary during "making" because their existence enables cooperation and sharing and stimulation of works. The last P stands for "play," that is, tackling experimental challenge in a playful and fun manner. Notably, the four Ps of creative learning overlap with the principles of creative learning spiral.

In other words, the notion presented overlaps with not only the online community of Scratch but also the sense of the "maker movement," where the concept of "learning by making" or "learning through making" has been spreading gradually in recent years (Martinez & Stager, 2013).

4 Pattern Language in Light of Constructionism

4.1 Patterns in a Pattern Language

This section discusses how pattern language should be considered on the basis of constructionism. First, pattern language is one that describes a collection of the rules of thumb in the field of designing or organizing practices. Practical knowledge in language is called "pattern," which includes wisdom and arts within a certain domain of expertise. Each pattern is basically structured in four parts, namely, context, problem, solution, and consequence.

Importantly, a name is assigned for each pattern (Fig. 6). More than tips and techniques to improve a situation, pattern language provides a new vocabulary, which can be used to think and communicate on good practice. Using words for practices renders thinking and communicating on how to improve situations easy. Notably, although each pattern is written to improve action in a specific situation, the entire language is intended to improve quality as a whole (Fig. 7).

4.2 Learning Patterns from the Viewpoint of Constructivism

Focusing on pattern language from the viewpoint of constructivism, patterns clearly cannot be directly imported into one's understanding because recognition and knowledge must be constructed internally (Iba and Munakata, 2019). Figure 8 shows that learning patterns should be considered as follows: First, patterns guide actions in certain situations and improve actions to consequences. Through this experience, schéma and structure are constructed internally instead of pattern description being imported into knowledge (Fig. 8)

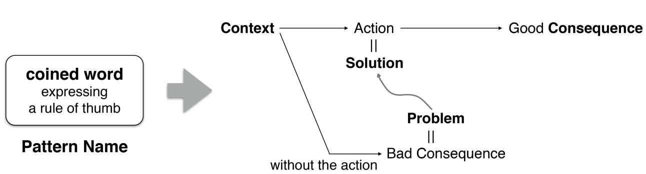

Figure 6: Give words to context, problem, solution, and consequence

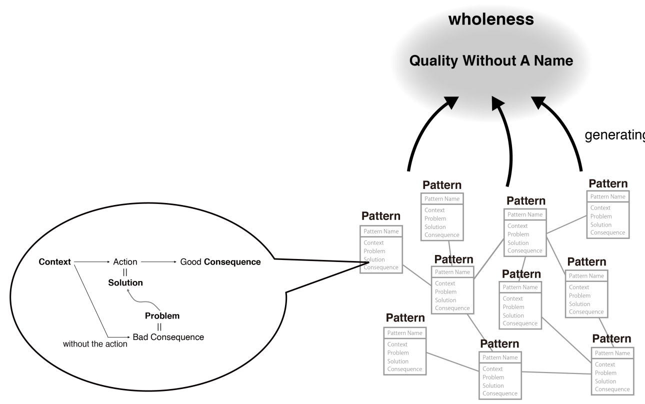

Figure 7: Multiple patterns enhance the quality of practice as a whole

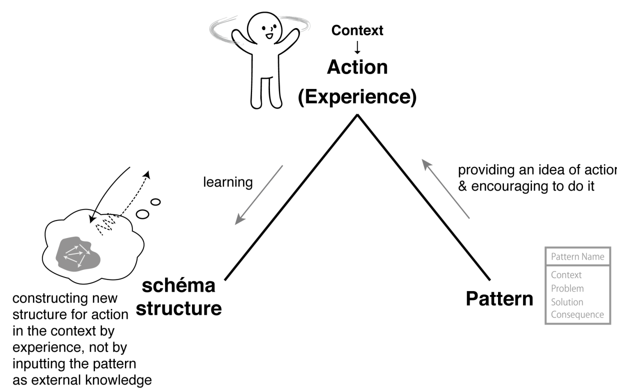

Figure 8: Contribution of pattern languages to the construction of schéma and structure (Iba & Munakata, 2019)

4.3 Functions of Pattern Language from the Viewpoint of Constructionism

First, by defining the ideal methods for design and practice, pattern language can support the practice of making (Fig. 9). For example, design patterns, such as software design (Gamma et al., 1995), provide knowledge on making suitable designs. Therefore, individuals can actually design things using the patterns as hints. A pattern language for human actions (Iba, 2016), including project design patterns (Iba and Kajiwara, 2019) and collaboration patterns (Iba and Iba Lab, 2018), provides hints to improve practice, such as launching a new project or collaborating with others.

Secondly, pattern language is useful in the debugging in process of making. Pattern language provides reference for improving a situation in the face of problem. According to Alexander et al. (1975) and Alexander (1979), pattern language was devised to achieve piecemeal growth through "diagnosis and repair." For this reason, the function of pattern language is vital.

Thirdly, in collaboration with multiple parties, pattern language becomes a common language among members of a group (Fig. 10). This situation can occur in a group within the same space, as Papert imagined, or with online members separated geographically, as Resnick assumed. In such a collaborative team, pattern language supports communication in terms of design and practices by providing a common set of vocabulary.

Through practices empowered by pattern language, people obtain and learn from rich experiences. Such a function is characteristic of pattern language from the viewpoint of constructivism, specifically constructionism.

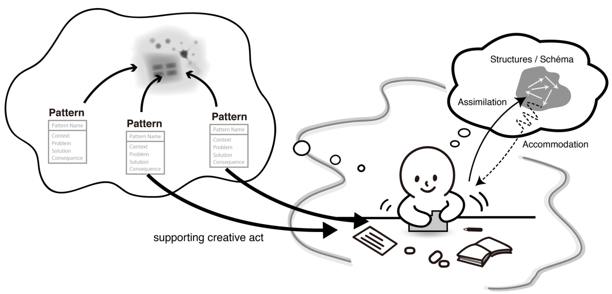

Figure 9: Patterns support making and debugging

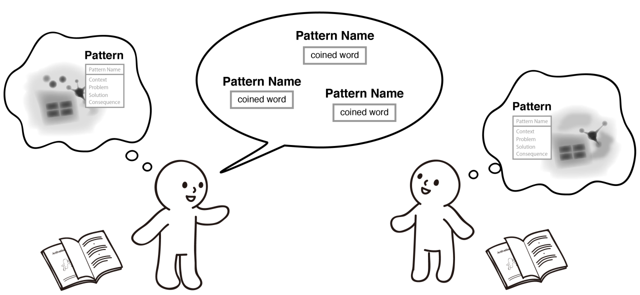

Figure 10: Pattern language functions as vocabulary for communication on design and practices

4 Conclusion

The study presented constructionism as proposed by Seymour Papert, which especially focuses on learning by creating and debugging and is one of the constructivism theories. Then, pattern language was discussed and the means by which it supports practice and learning from the viewpoint of constructionism. Notably, the remaining papers of this four-part series have discussed constructivist learning theories proposed by Jean Piaget (Iba and Munakata 2019), Lev Vygotsky (Iba and Burgoyne, 2019a), and John Dewey (Iba and Burgoyne, 2019b). Figure 11 provides an overview of the history of these theories. The present study recommends a perusal of such papers in the series. In addition, the paper intends to make a contribution to the literature by providing reference to decision-makers, educators, and other stakeholders who are interested in promoting education that fosters creativity and uses pattern language to support this end.

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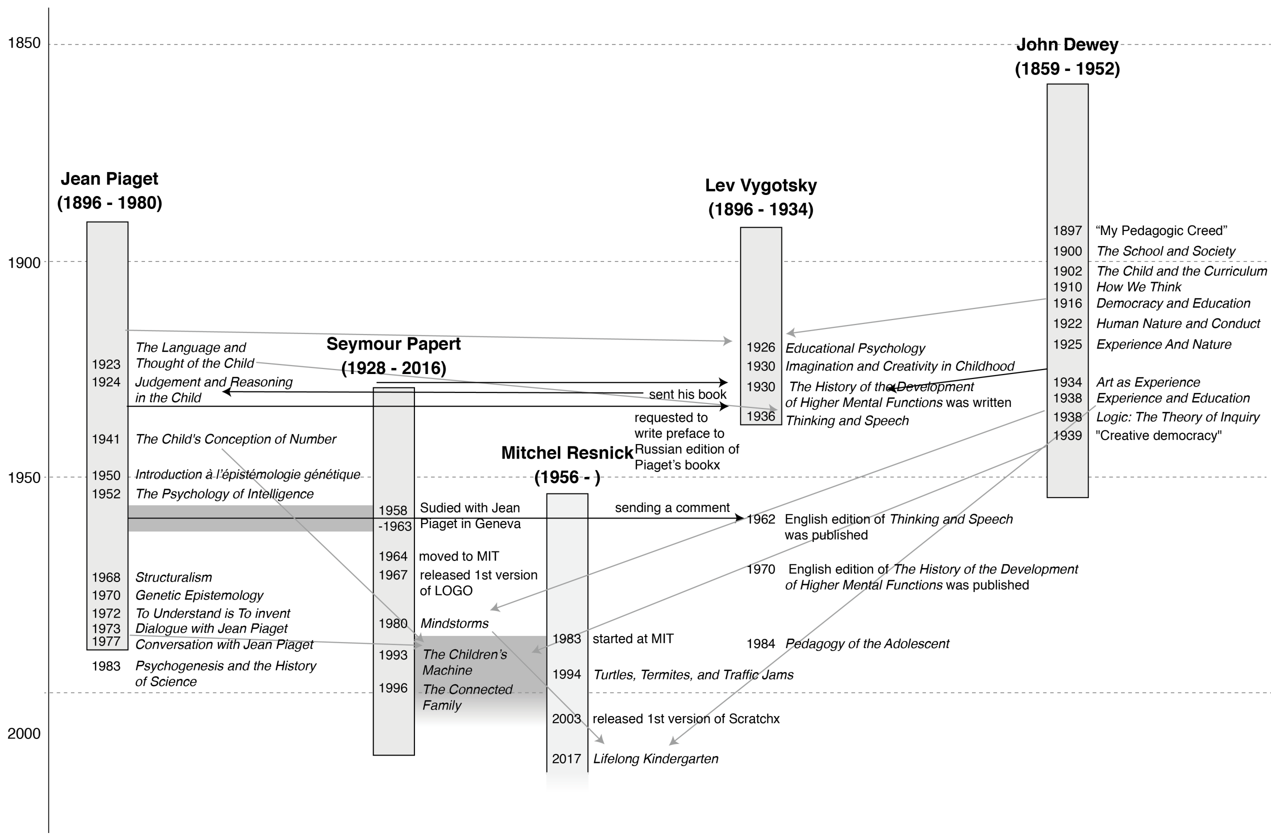

Figure 11: Overview of the history of constructivist learning theories