From Nine Events of Instruction to the First Principles of Instruction: Transformation of Learning Architecture for Society 5.0

Katsuaki Suzuki(✉)

Research Center for Instructional Systems, Kumamoto University, 2-40-1, Kurokami, Kumamoto 860-8555, Japan
ksuzuki@kumamoto-u.ac.jp

Abstract. This keynote addresses a needed shift in designing learning architecture for transforming education to meet the needs of Society 5.0, Super Smart Society. *Classroom of the Future Project* is reviewed to image the transformation of education being sought in Japan. The *Nine Events of Instruction*, a traditional instructional design theory proposed by Robert M. Gagne, will be reviewed as a framework for facilitating human learning based on information processing theory. It will then be compared with a more recent framework of the *First Principles of Instruction*, proposed by M. David Merrill, reflecting various theories and models proposed based on constructivist psychology. Similarities and differences will be discussed to suggest how to utilize them as an architectural framework for blended learning design toward a more learner-centered self-directed learning environment, toward so-called Society 5.0.

Keywords: Instructional design · *Nine Events of Instruction* · *First Principles of Instruction* · Society 5.0 · *Classroom of the Future Project*

1 Introduction

Educational Technology has been a field of study that lasted long and has evolved in relation to the advancement of technology, from teaching machines, radio and television, computer-assisted instruction, to Web-based training and online education [1]. It has been anticipated that a super smart society is just around the corner as the next phase of society after information and communication technology (ICT) society. Japanese government selected the term Society 5.0 [2] for such a super smart society, based on Internet of Things (IoT) technology, to make all the services available anytime, anywhere, and to anybody. It is named Society 5.0, because it comes after the hunting society (Society 1.0), the farming society (Society 2.0), the industrial society (Society 3.0), and ICT society (Society 4.0). However, as Marc Prensky [3] suggested, we may still be trying to educate *Digital Natives* who were born with digital technology, and who will become the major actors of Society 5.0, with an outdated way of education. Most current teachers who teach the Digital Natives are *Digital Immigrants* who had grown up in older societies

R. Li et al. (Eds.): ICBL 2021, LNCS 12830, pp. 3–15, 2021.
https://doi.org/10.1007/978-3-030-80504-3_1

without digital technology. We may still be trying to make our children function well in an assembly line of Society 3.0, if not trying to make them function well now, but soon be substituted by Artificial Intelligence. It is the time that major transformation should be brought to education to better meet the new needs of the future, which is not an easy task, but essential to make Society 5.0 a reality.

This paper will discuss how we can prepare such transformation in two ways. First, a recent attempt by Japanese government will be introduced to form a concrete image of what can be done to make a major shift in school curriculum. Second, a shift in the background theories of instructional design will be explained by comparing and making contrast of two well-known models. It is the author's hope that the concrete image can be supported by theoretical architecture so that the transformation will be designed in all and every contexts of education today.

2 MITI's *Classroom of the Future Project*

As an example of efforts to transform current schools to fit the needs of Society 5.0, The Japanese Ministry of International Trade and Industry (MITI) has launched the *Classroom of the Future Project* in 2018 [4]. MITI intends to corporate with The Ministry of Education (MEXT), from the education industry sectors, to make what is written in the K-12 new standard course of study a reality by the alliance (See Fig. 1). *GIGA Schools Initiative*, GIGA as an acronym for *Global and Innovation Gateway for All*, represents such METI/MEXT corporation for innovation in education, in which Tablet PCs are to be provided to all pupils with high-speed network. The initiative has been accelerated due to the school shutdown occurred in 2020 by the COVID-19 pandemic.

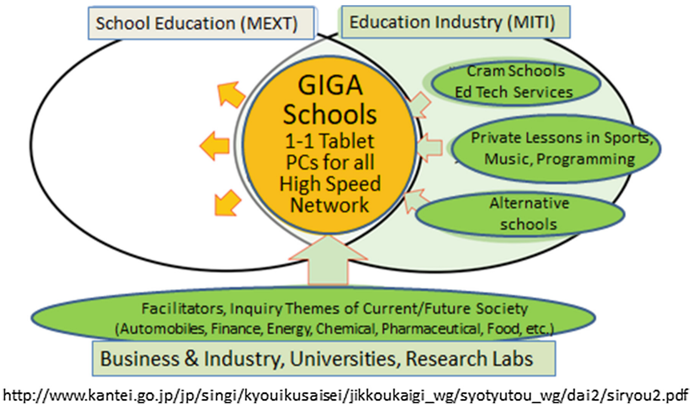


Fig. 1. METI/MEXT Corporation for Innovation in Education in Japan Note: English is provided by the author as unofficial translation.

Figure 2 represents MITI's concept for the *Classroom of the Future Project*. Although MITI deals with Education Industry sectors, its current focus lies in the K-12 schools, with the keywords "Converting school learning to STEAM (Science, Technology, Engineering, Arts, and Mathematics) with personalized and optimized learning." The aim is to form cycles of inquiry-based projects at creation level, with acquisition of necessary basic knowledge and skills, so that interdisciplinary learning can be started from young ages and continued to be at the center of the curriculum. The cycles create the reason to learn basics that could be boring and tedious without clear and immediate needs at hand. Pupils naturally see the reason why they need to learn the basics, because they are to be utilized as the project progresses. Without basics, nobody can create meaningful artifacts in any project. However, basics can be acquired on time and on demand, whenever needed by the project, without spending so much time learning only basics first. This is claimed to be a more exciting way of learning for each pupil, which can be helped by technology managing personal learning plans and learning pathways of all students engaging in different projects.

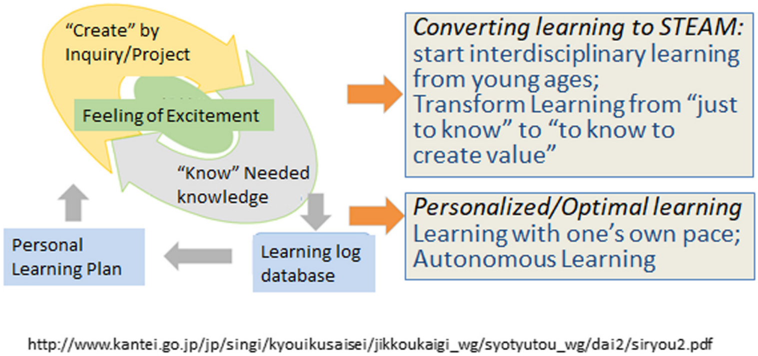
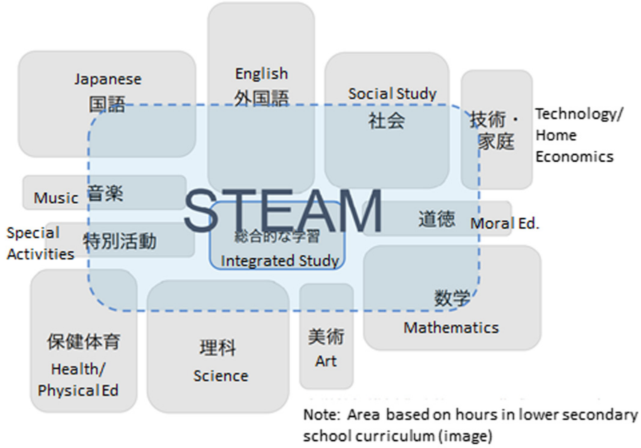


Fig. 2. METI's concept for *Classroom of the Future Project* Note: English is provided by the author as unofficial translation.

In order to assure enough school time for interdisciplinary STEAM education, it is suggested to make learning basic knowledge and skills in all subject matter more personal and optimal, by utilizing EdTech and one-on-one PCs provided by *GIGA School Initiative*. The more efficient it becomes to learn basics, the more time it creates for the STEAM projects. Figure 3 shows such reduction of class time in all subject areas, in addition to currently allocated time for Integrated Study, would be devoted to STEAM education at the central core of the curriculum.



http://www.kantei.go.jp/jp/singi/kyouikusaisei/jikkoukaigi_wg/syotyutou_wg/dai2/siryou2.pdf

Fig. 3. STEAM at the core of curriculum connected with all subject matters Note: English is provided by the author as unofficial translation.

Many innovative practices have been reported until today. Table 1 shows some examples.

Table 1. Examples of innovative practices in GIGA School Initiative

Adapted Math drill with Robot workshops (Junior High School)	Stop whole classroom teaching and substitute it with AI-based one-on-one math drills to make basic learning more efficient by adjusting to individual math skills. Apply learned math skills to manipulate a robot in a STEAM workshop, making it possible how the acquired math skills are necessary in technology available in society
Individual allocation of learning time to overcome weak subject matters (Junior High Schools)	Utilize individually adapted learning materials to spend time in a weak subject matter, so different students worked on different subjects simultaneously. Created more motivation for learning
Teacher's talk reduced to only 5-min introduction (Elementary school arithmetic)	Utilize one-on-one PCs to learn arithmetic individually as well as cooperatively, to make learning more autonomous and helping each other. More supportive conversation observed
English writing with help of international college students online (High School English)	High school students engage in self-regulated learning with feedback given through online by native college students. More output was produced with more natural composition

(*continued*)

Table 1. (*continued*)

Regional Online Learning Support Center to help pupils with needs	No-one-left-behind concept was introduced to initiate a new Learning Support Center, where monthly interviews were conducted to help all learners create individual learning plan and provide both online (including real-time and on-demand) and offline support to monitor the progress

Source: http://www.kantei.go.jp/jp/singi/kyouikusaisei/jikkoukaigi_wg/syotyutou_wg/dai2/siryou2.pdf.
Note: English is provided by the author as unofficial translation.

Many sample materials for STEAM projects can be found in MITI's STEAM Library Website (https://www.steam-library.go.jp/). They are products created through cooperation of schools, companies and academic institutions, which have been made available for the uses by other schools. Each material is linked to UNESCO's SDGs (Sustainable Development Goals). Table 2 shows some of the examples.

Table 2. Sample titles and related SDGs in STEAM Library

Title	Related SDGs
Is it possible for humans to survive in the universe? (for Elementary Schools)	3, 8, 9
Veggie Meat (business plan, market analysis, plant-based meat)	2, 3, 8, 9
Drone (Society 5.0, design, engineering, presentation)	3, 7, 8, 9
Future Energy (active learning, problem solving)	1, 2, 3, 4
Exploring Comfort (Junior/Senior High School)	1, 2, 3, 6
Disaster Control through Technology (Robot, disaster prevention, natural disaster, inquiry)	9, 11, 13

Source: https://www.steam-library.go.jp/

3 Learning Architecture Models

Until today, various research outcomes have been made available from educational technology research, focusing on how to construct the architecture of learning environment, in the form of various theories and models for instructional design and technology [5–7].

3.1 Gagne's Nine Events of Instruction

The *Nine Events of Instruction* is a traditional instructional design theory proposed in the 1970's by Robert M. Gagne [8]. It was proposed, based on a framework of cognitive psychology, to design nine different kinds of activities (instructional events, in his term) to be included as components of instruction for facilitating human learning. If instruction is to be structured in such a way to facilitate human learning effectively, it should have distinct features of assisting learners process information with multiple phases. It includes alerting for information processing activities, sensing and selecting relevant information, retrieving already learned basics from one's memory, blending them with newly presented information to make connections with semantic networks within the long-term memory, and practicing retrieval and application of the newly acquired knowledge and skills. Such terms as sensory resister, working and long-term memories, retrieval practice are taken from the information processing theory of human learning, by making an analogy to information processing phases of computers. Table 3 lists the *Nine Events of Instruction.*

Table 3. Nine Events of Instruction

	Events of Instruction	Functions
Introduction (Preparation)	1. Gaining learners attention	Alert for the start of learning
	2. Informing learners of the objectives	Help focusing on the goal of learning
	3. Stimulating recall of entry conditions	Help remembering basics from prior learning
Presentation (Input)	4. Presenting new information	Show the contents of new learning
	5. Providing learning guidance	Help make connections of new items with prior learning to expand semantic network of knowledge and skills
Practice (Output)	6. Giving opportunities to practice	Provide chances to retrieve or apply newly learned knowledge/skills
	7. Providing feedback	Give corrective feedback for mastery
Evaluation	8. Assessing learning performance	Confirm the mastery of new learning
Review	9. Enhancing retention & transfer	Provide review opportunities with intervals and enhance application skills

Since then, Gagne's *Nine Events of Instruction* has been widely used as a framework for designing instruction. It has been one of the most frequently utilized frameworks for designing instruction, together with his categorization known as five learning outcomes (verbal information, intellectual skills, cognitive strategies, motor skill, and attitudes). That is, the nine events are commonly needed for all kinds of learning outcomes, whereas what should be included in each event would be unique for each learning outcome. For example, mnemonics may be effective for remembering verbal information, whereas showing diversity of instances be effective for acquiring intellectual skills. Human models may be effective for learning attitudes, whereas help forming a mental image of execution be effective for motor skill learning. They are the variety to accomplish the same Event 5, Providing Learning Guidance; all other events should also be implemented differently, according to the nature of learning outcome.

If one will design individually adaptive and optimal learning material, as an efficient way of learning the basics in less time, as proposed in MITI's project described above, *Nine Events of Instruction* can be consulted. It will show how much of necessary steps (events) is equipped in each material, whether it is AI-based or not. Any drill-type materials may not have all the events, but mainly consists of Events 6–8. However, if a learner has problem too big to be covered by giving corrective feedback, then some elements of tutorials (Events 4 and 5) may be effective addition to such adaptive learning environment. It may also be beneficial for a learner to be provided a review opportunity (Event 9), based on learning trajectory records of the last attainment date of a mastery. Although Gagne's model is traditional that has been used more than 50 years, it may still be useful to create an adaptive learning architecture for individual learning of the basics. Appendix A shows some sample instructional strategies based on Gagne's model.

3.2 Merrill's First Principles of Instruction

A more recent framework, the *First Principles of Instruction*, was proposed by M. David Merrill in 2002, reflecting various theories and models proposed based on constructivist psychology [9, 10]. It was named the first principles, because the five features consisting of Merrill's model (see Fig. 4) were claimed to be common in most of the constructivist instructional design models proposed at that time.

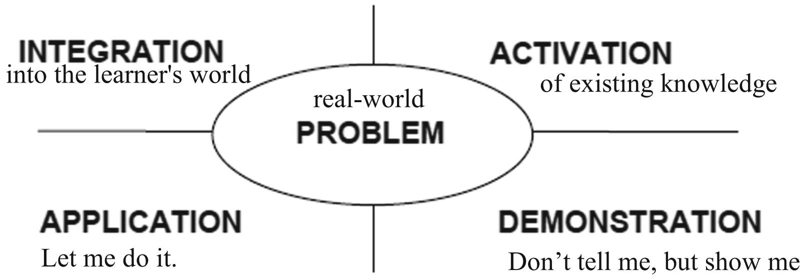


Fig. 4. First principles of instruction diagram

According to Merrill's *First Principles of Instruction*, every instruction should have the following 5 elements to be effective, efficient, and engaging, and to become "5-star instruction":

1. *Real-world Problem*: Learning is promoted when learners acquire knowledge and skill via a problem-solving strategy in the context of real-world problem or tasks.

2. *Activation*: Learning is promoted when learners activate an existing mental model as a foundation for new skills.
3. *Demonstration*: Learning is promoted when learners observe a demonstration of the skill to be learned that is consistent with the type of skill being taught.
4. *Application*: Learning is promoted when learners engage in the application of their newly acquired knowledge and skill that is consistent with the type of content being taught.
5. *Integration*: Learning is promoted when learners reflect on, discuss, and defend their newly acquired skills.

In recent works of instructional design literature, Merrill's *First Principles of Instruction* has been adopted as the foundation for common knowledge base [6], as well as toward creating learner-centered education [7]. More detailed situational design principles have also been proposed to elaborate on Merrill's *First Principles of Instruction* for such diverse sets as discussion approach, experiential approach, problem-based approach, and simulation approach [6]. Another book further elaborated for steps toward learner-centered paradigm of education, in relation to maker-based instruction, collaborative digital multimedia creation projects, gamification and game-based instruction, and instruction for self-regulated learning [7].

If one will design STEAM project as the second core of transformed school education, with adaptive and optimal individual learning, as proposed in MITI's project described above, *First Principles of Instruction* can be consulted. It will be a useful tool to examine if the main features of the 5 principles are covered in the design of STEAM project. How each and every *First Principles of Instruction* can be implemented that fits chosen approach toward problem-based projects? Is there better approach available for a given project to a given set of learners? Those questions can be answered by referring to the *First Principles of Instruction* themselves, as well as more elaborated situational principles proposed later. Merrill's *First Principles of Instruction* can be adopted as the theoretical architecture when designing STEAM projects, with which a firm understanding of human learning can be incorporated in the project design, as well as practical suggestions can be obtained. Appendix B shows some sample instructional strategies based on Merrill's model, with author's interpretations to better fit of them in the context of transformation toward Society 5.0.

4 Conclusion

This paper discussed how we can prepare transformation toward realizing Society 5.0 in two ways. First, *Classroom of the Future Project* was introduced as a recent attempt by Japanese government to form a concrete image of what can be done to make a major shift in school curriculum. Second, a shift in the background theories of instructional design was explained by comparing and making contrast of two well-known models: Gagne's *Nine Events of Instruction* and Merrill's *First Principles of Instruction.* It is the author's hope that the concrete image can be supported by theoretical architecture, so that the transformation will be designed in all and every contexts of education today, in a better and surer way. Society 5.0 needs be proactively designed from transformative efforts in Education sectors, so that children would be able to contribute to shape such a society, not to be struggled in rapid changes of society.

Appendix A: Instructional Strategy Sampler Based on Gagne's Nine Events of Instruction

1. Gaining Learner's Attention
Let the students ready to start learning by:

☐ Start off with some episode, anecdotal, or some issue directly related to the main theme.
☐ Start off your instruction with something unusual, strange, and abrupt.
☐ Seek for something fresh so that the students will not feel "Oh, this one again?"
☐ Use issues, conflict, new fact to override students existing frame of mind.

2. Informing Learner of the Objective
Activate student thinking and let them concentrate key points by:

☐ Make the theme of the lesson visible and clear so the students will not spend time mindlessly
☐ Establish learning contract with students as to what to teach and what to learn
☐ Use plain language of the students to convey the learning objectives clearly
☐ List the checkpoints as to what are the key points of the unit
☐ Help the students find the value by showing how the unit at hand will be useful in their future
☐ Verify where the goal is so that the students themselves can realize when they accomplish it.

3. Stimulating Recall of Entry Conditions (Prior Learning)
Help the students retrieve what they have already learned from their brain by:

☐ Provide a review to refresh students' mind about basics needed for the unit at hand
☐ Specifically identify how the basics of previous learning will relate to today's learning
☐ Embed in the material triggers for remembering the basics, assuming that everything the students have learned in previous unit/lesson is already forgotten
☐ Use small quiz, question, or short review at the beginning of each unit for reviewing the basics.

4. Presenting New Information (Stimulus Materials)
Show the students what are the things they are expected to learn by:

☐ Clearly organize the new information to show the students rules and examples of new learning
☐ Use concrete and familiar examples of new concepts or rules, not just vague statements of concepts or rules themselves

☐ Ask the students to evoke the images that are familiar to their own experiences or environments
☐ Provide a simple, representative case first, then proceed to more complex cases with variations
☐ Use illustrations, figures, and tables to easily capture new materials as a whole, the position of an element, and relationships of that element to other elements.

5. Providing Learning Guidance
Help the students to remember new information/skills in a meaningful way by:

☐ Connect the newly presented information to what the students already know so that they can form a network of information in a meaningful way
☐ Use mnemonic devices, anecdotal, comparisons to more familiar basics, to provide a hint for remembering the new information
☐ Give the students many hints for understanding, and let them accustomed to the use of hints.

6. Giving Opportunities to Practice (Eliciting Performance)
Let the students have opportunities for practicing new contents by:

☐ Give the students enough chances of practice in a risk-free situation so they can find their weak points without punishment
☐ Let them try first, without seeing examples, so they know if they can do it by themselves
☐ Provide cues for earlier stages of practice, and gradually remove them as they master the skill
☐ When application skills are required, have them practices in diverse settings.

7. Providing Feedback
Help the students find weak areas to improve their knowledge/skills by:

☐ Provide informative feedback messages for incorrect answers so the students realize how to fix the problem
☐ Avoid negative feedback to highlight their failures
☐ Give the students appraisals for correct answers, and guidance for incorrect answers.

8. Assessing Learning Performance
Provide tests to verify what the students have become able to do, and feel good about their accomplishment by:

☐ Give the students enough practice opportunities before they are to take a test
☐ Construct a test with enough number of items so that only those who mastered the contents, not the lucky students, can pass the test
☐ Match the test with previously stated objectives and the contents of learning materials, no surprise on the test. Do not test what the students have never been taught.

9. Enhancing Retention & Transfer
Help the student sustain what they mastered and make the new learning applicable to other situations by:

☐ Schedule re-tests when they will be forgotten the new learning, since everyone remembers very little as time goes by
☐ When reviewing, do not let them study the materials that contain answers, but let them try practice items first without seeing the text, to find out how much they remember
☐ Provide application scenarios so that they can use the newly learned knowledge/skills
☐ Provide advanced exercises as an option at the end of each unit, but not as a requirement.

Note: Originally created by Katsuaki Suzuki in 2017.

Appendix B: Instructional Strategy Sampler Based on Merrill's First Principles of Instruction

1. Real-World Problem

☐ Show the task that they will be able to do or the problem they will be able to solve as a result of completing a module or course (i.e., Learning objective).
☐ Challenge the learners if they can solve real-world problems (i.e., Pretest).
☐ Engage the learners with the whole-task problems, not just the basic operation or action level.
☐ Let the learners solve a progression of problems that are explicitly compared to one another.

2. Activation for Diagnosis

☐ Let the learners try to solve the problem by activating relevant previous experiences before teaching. Diagnose missing parts in their solution; if their solution is satisfactory, then no need for training thus finish training without teaching (cf. TOTE model).
☐ Direct the learners to recall, relate, describe, or apply knowledge from relevant past experiences that can be used as a foundation for solving this new problem.
☐ Provide with a relevant experience that can be used as a foundation for the new knowledge.
☐ Give the opportunity to demonstrate their previously acquired knowledge or skill.

3. Demonstration

☐ Demonstrate what is learned, rather than merely telling information about what is to be learned.
☐ Make demonstration consistent with the learning goal: (a) examples and non-examples for concepts, (b) demonstrations for procedures, (c) visualizations for processes, and (e) modeling for behavior.

☐ Provide with appropriate learner guidance including some of the following: (a) learners are directed to relevant information, (b) multiple representations are used for the demonstrations, or (c) multiple demonstrations are explicitly compared.
☐ Make media play a relevant instructional role.

4. Application

☐ Require the learners use their new knowledge or skill to solve similar but new problems.
☐ Make application (practice) and the posttest consistent with the stated or implied objectives: (a) information-about practice – recall or recognize information, (b) parts-of practice – locate, name, and/or describe each part, (c) kinds-of practice – identify new examples of each kind, (d) how-to practice – do the procedure and (e) what-happens practice – predict a consequence of a process given conditions, or find faulted conditions given an unexpected consequence.
☐ Guide the learners in their problem solving by appropriate feedback and coaching, including error detection and correction, and when this coaching is gradually withdrawn.
☐ Require the students solve a sequence of varied problems.

5. Integration

☐ Encourage learners transfer to the new knowledge or skill into their real-life job settings.
☐ Give the learners an opportunity to publicly demonstrate their new knowledge or skill.
☐ Let the learners reflect-on, discuss, and defend their new knowledge or skill.
☐ Let the learners create, invent, and explore new and personal ways to use their new knowledge or skills.

Note: Originally created by Katsuaki Suzuki in 2021.

References

1. Reiser, R.A.: A history of instructional design and technology (Chapter 2). In: Reiser, R.A., Dempsey, D.V. (eds.) Trends and Issues in Instructional Design and Technology, 4th edn., pp. 8–22. Pearson Education (2018)
2. Society 5.0, Cabinet Office, Japan. https://www8.cao.go.jp/cstp/society5_0/index.html
3. Prensky, M.: Digital natives, digital immigrants. In: On the Horizon, vol. 9(5). MCB University Press (2001)
4. Ministry of International Trade and Industry (MITI): Classroom of the Future Project (2018). https://www.learning-inovation.go.jp
5. Reiser, R.A., Dempsey, D.V. (eds.): Trends and Issues in Instructional Design and Technology, 4th edn. Pearson Education, New York (2018)
6. Reigeluth, C., Carr-Chellman, A.A. (eds.): Instructional-Design Theories and Models, Volume III: Building a Common Knowledge Base. Routledge, New York (2009)
7. Reigeluth, C., Beatty, B.J., Myers, R.D. (eds.): Instructional-Design Theories and Models, Volume IV: The Learner-Centered Paradigm of Education. Routledge, New York (2016)
8. Gagne, R.M.: The Conditions of Learning and Theory of Instruction, 4th edn. Wadsworth Pub, New York (1985)

9. Merrill, M.D.: First principles of instruction. Education Tech. Research Dev. **50**(3), 43–59 (2002)
10. Merrill, M.D.: M. David Merrill's First Principles of Instruction, rev. ed. Association for Educational Communications and Technology (2020)