CU1

Foundation for ID

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Introduction

The European Instructional Designer (EID) curriculum identifies 7 Competence Units (CUs) that are necessary for instructional designers to design and develop functional and inclusive instruction. This competence unit - Foundation of ID - introduces foundational knowledge and skills for instructional design with five topics that are seen as essential to grasp what instructional design is, what instructional designers' responsibilities are, and how instructional designers develop instruction in a project to solve instructional problems. This CU also aims to raise awareness of the instructional designer's disposition as a reflective problem-solver with critical and intercultural perspectives. At the end of CU1, you are expected to:

1. Understand instructional design as a process of combining learning theories and instructional design principles to develop functional instructional solutions;
2. Understand instructional design as an iterative problem-solving process that produces instructional solutions according to the specific instructional context (i.e., the learning needs, target/potential users, and existing learning environment);
3. Recognize the role and value of instructional development models and understand the diverse roles of management, communication, and technology in an instructional design project;
4. Develop awareness of the instructional designer identity as a continuous-developed professional who actively engages in interdisciplinary learning through collaborations that draw upon and develop multiple perspectives and intercultural competences.

Corresponding the eLearning screen materials, this document presents more extensive materials for the following 5 topics:

- **Instructional design - an Interdisciplinary wonderland**
- **Learning theories and instructional-design theories**
- **Instructional design as a complex system**
- **Instructional development (ID) models and principles**
- **Identity of an instructional designer**

Instructional design - an interdisciplinary wonderland

Instructional design - an interdisciplinary wonderland

Instructional science is a field that tries to identify essential variables (e.g., learning objectives, assessment methods, learning activities, instructional methods, etc.) and potential relationships between these variables within (complex) learning and instructional environments. Through ongoing theoretical and empirical testing of their impact on human learning, these relationships are explored and developed into instructional strategies that produce learning experiences for learners (Reigeluth, 1999). Instructional science develops along the development of learning science that attempts to understand learning from a broad range of perspectives and to shape the ways of designing learning environments and resources (Nathan & Sawyer, 2022).

Instructional Strategies
Instructional strategies are the techniques and practices instructors use to provide effective and productive learning.

Learning Experiences
Learning experiences refers to the experiences in which learning takes place in a variety of settings (e.g., classrooms and workplaces).

Relying on learning principles and instructional strategies developed from learning and Instructional science, instructional design is a problem-centered process that involves a number of complex tasks that in themselves also involve subtasks. The problem-centered process develops alternative instructional solutions that arrive at a complex and dynamic learning environment (Chou & Wong, 2015). The resulting learning environment provides a series of instructional and learning activities (i.e., engaging students in learning activities, promoting target knowledge acquisition and construction, facilitating participation in the community of practices, and providing constructive feedback for learning) that aims to create learning experiences that support learners to reach the learning objectives.

Let's take an example that you (or your design team) plan to develop training – Computational and algorithmic thinking in programming. To develop the training, you might engage in but not limited to the following instructional design activities:

- active communication with stakeholders (i.e., clients, learners, and your design team) regarding the training needs, goals, and requirements;
- analysis and organization of the learning content and learning process (e.g., programming language, computational and algorithmic thinking in problem-solving, etc.);
- application of learning principles instructional strategies and user-experience (UX) design to develop interactive and constructive learning experiences for learners to achieve the learning objectives;
- implementation of the training and evaluation of its effectiveness, but potentially also evaluation of the quality of each phase of the design process;
- integration of technology (most likely in current society) to support both the instructional design process and learners' learning experience.

In order to create the desired learning experiences and functional instruction, instructional designers should:

1. be aware of the interconnection among users, instructional problems, and instructional contexts (e.g., resources, supports, budgets etc.) in the instructional design process, and use a **user-centered** and **problem-centered design approach** that involves **multi-stakeholder collaboration** in order to solve the problem;
2. acknowledge the diverse interactions within a learning environment and the necessity of using learning theories and instructional design theories to develop learning experiences.

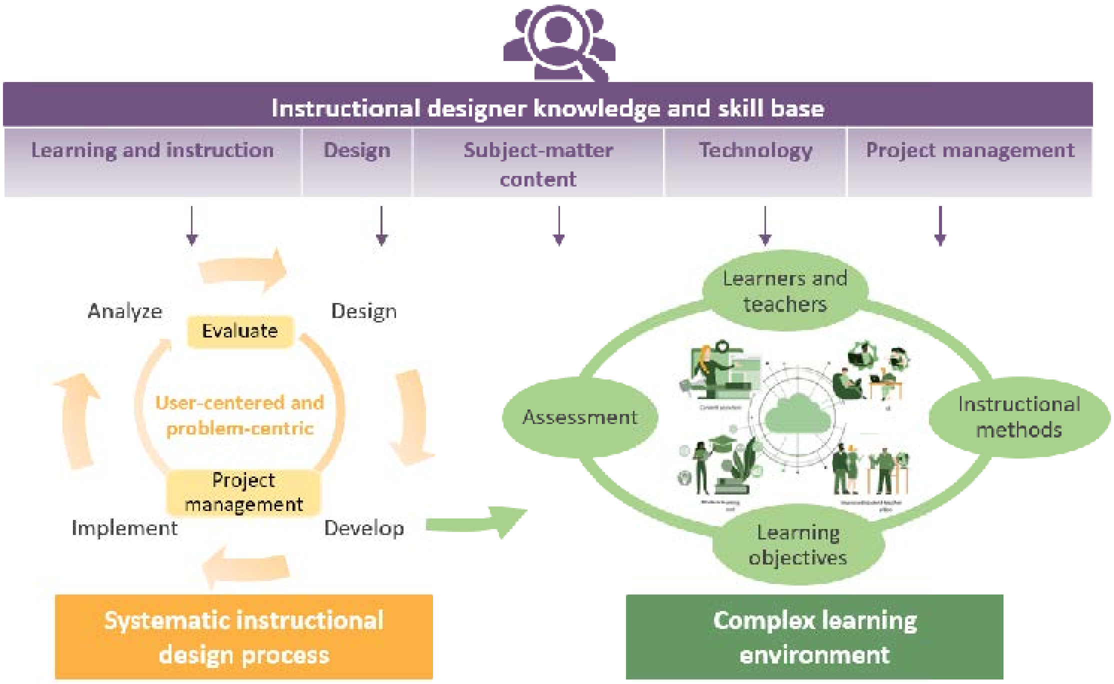

Figure 1 ID as an interdisciplinary wonderland

In order to recognize the complexity and dynamism of the instructional design process and the resulting complex learning environment as an outcome of a design processinstructional designers engage in developing and utilizing interdisciplinary knowledge and skills in the fields of:

- **Learning and instruction:** The nature, theories, and practices of learning and instruction, based on which learning environments and instructional practices are developed;
- **Design:** The strategies and practical procedures to design functional products;
- **Subject-matter content:** The knowledge and skills within and attitudes towards a specific subject that should be conveyed during the instruction process;
- **Technology:** The application of technology to reach practical goals in the design process and the resulting instruction in a specifiable and reproducible way;
- **Project management:** The coordination and management of work tasks to achieve project goals with specific context constraints.

During the instructional design process, knowledge and skills from different disciplines play more or less essential roles depending on the current design activities and proactively and reactively contribute to shaping design processes and instructional design products over time. They are always important for guiding instructional designers' decision-making and practices. It is, therefore, important that instructional designers continue to develop their expertise in these diverse fields in real-world instructional design projects.

However, the notion of interdisciplinary knowledge and skills should not be confused with the need of being to be an expert in all these fields as an instructional designer. It is equally important to recognize the need for collaboration when other expertise is required (e.g., related to the subject-matter content, the learners, and the environment). Subject-matter content knowledge and skills are not addressed in this CU since the domain knowledge varies from project to project. However, an instructional designer should preferably understand the to-be-taught content to some extent and that active collaboration with subject-matter experts is always beneficial (Mudd, Summey, & Upson, 2015).

In general, relying on **interdisciplinary collaboration** is one of the main strategies for instructional design teams to systematically and iteratively target multiple components of instruction in tandem. The diverse inputs generate different partial solutions that can then be brought together to produce unified and coherent instruction (Anushree et al., 2021).

Learning theories and intructional design theories

Learning theories and instructional design theories

Learning theories describe the nature of learning, providing multiple perspectives on when, how, and why various types of learning happen. **Instructional-design theories** provide guidelines in the practices that can facilitate learning based on scientific learning principles implied by learning theories.

Instructional design is a design-theory-driven field that links learning science and real-world instructional practices via systematic and creative design practices and management, nowadays, often in a technological-assisted environment. In order to develop functional instruction, instructional designers apply instructional design theories to develop instructions and learning environments that support learners to engage in learning and attain learning outcomes as planned

However, it is important to understand that instructional designers are not just "technicians" following and applying practices from instructional design theories. Instructional designers routinely utilize and refer to learning theories.

> *"Learning and developmental theories are useful for understanding why an instructional-design theory works, and, in areas where no instructional-design exists, they can help an educator to invent new methods or select known instructional methods that might work". (Reigeluth, 1999, p.13)*

Therefore, it is crucial for instructional designers to understand both learning theories and instructional design theories to identify when, how, and what, and to explain why specific instructional practices can support the target learning.

Learning theories

Learning is a complex phenomenon having "its foundation of the systemic, dynamic, and interactive relation between the nature of learners and the object of the learning as ecologically situated in a given time and context as well as overtime" (Alexander et al., 2009). Perspectives on learning (i.e., **behaviorism, cognitivism, constructivism,** and **sociocultural learning**), explain different sorts of learning, including some that involve the acquisition of knowledge and skills, and some that involve the formation of dispositions in communities (Phillips & Soltis, 2009).

Behaviorism

Behaviorism defines knowledge and skills as observable and measurable behaviors. Learning is a process of accumulating knowledge (behaviors or performances) through building associations of **external stimulus** and **response** with **external consequences** (i.e., **reinforcement** or **punishment**). For example, students get a small reward (reinforcement) if they get 100% of the score (response) on their vocabulary quiz test (external stimulus). Behaviorism could explain the learning of behaviors that can be decomposed as a narrow set of perceptual or motor skills (Nathan & Sawyer, 2022), for instance, recalling facts and automatically performing a specific procedure (Ertmer & Newby, 2013).

The basic behaviorist principles are still commonly used in instructional design for their effectiveness in eliciting the desired performance with stimulus. One example is one type of game-based learning that is founded on repetition and rewards. **Environment conditions**, the arrangement of stimuli and consequences that could elicit the target response, is the key factor that influences if learning (building stimulus-response association) is made, strengthened, and maintained (Ertmer & Newby, 2013). The behaviorist instructional design practices include:

- **Task analysis** to determine the behavioral objectives, instructional sequence (progressing from simple to more complex levels of performance), and instructional cues (i.e., external stimulus and consequences);
- **Design of instructional cues and reinforcements** for eliciting desired responses and strengthening correct responses with corrective feedback;
- **Learner analysis** with pre-assessment to determine learners' performance on prerequisite learning;
- **Design of practice situation** that prompts the association of stimuli and response in diverse performance settings;
- **Design of assessment** that examines learners' reproductive rate of desired responses.

However, behaviorism has its limitation in explaining learning that happens without conditioning. For example, young children can recognize the meaning of sentences and verbal constructions that they have never come across before or been reinforced to react to the sentences (Phillips & Soltis, 2009, pp.33). It also falls short in explaining the acquisition of higher-level skills, such as using prior knowledge to interpret external information, generating inference, learning language, and solving complex problems (Ertmer & Newby, 2013).

When higher-level learning outcomes are required, therefore, instructional designers should be aware of this limitation of behaviorism and emphasize learners as active learning agents instead of just being reactive to conditioning. These higher-level learning are better explained through other perspectives.

Cognitivism

Cognitivism defines knowledge as schema mapping the external world in learners' minds. Knowledge is stored in **long-term memory** that could be recalled for processing the external information in working memory (Sweller et al., 1998). Knowledge can be decomposed and simplified into basic building blocks, including declarative knowledge, procedural knowledge, and conditional knowledge (Winne & Azevedo, 2022). Learning is a process of encoding, organizing, analyzing, and structuring external information to form a schema or change the existing schema stored in memory by applying various cognitive strategies and meta-cognitive strategies (Ertmer & Newby, 2013). Learners' **prior knowledge** established boundaries for identifying the similarities and differences of various information during learning processes and the transfer of learning processes.

Schema
Schema represents the way of external information or objects are organized and stored in humans' long-term memory. It is recalled for learners to process the new presented information.

Working Memory
Working memory refers to human consciousness where cognitive functions work to process information in the sense of organizing, contrasting, comparing, or working on the limited amount of information hold in memory.

Declarative Knowledge
Declarative knowledge refers to the facts, information, concepts, and theories about a specific topic.

Procedural Knowledge
Procedural knowledge refers to the information lists steps for performing cognitive work tasks, for example, a method for narrowing search of the Internet.

Conditional Knowledge
Conditional knowledge refers to the information the identifies circumstances in which a declarative knowledge is valid or a procedural knowledge is appropriate for approaching a goal.

Cognitive Strategies
Cognitive strategies are strategies used to faciliate information encoding, organizing, memorizing and retriving. It includes but not limited to repeatition, information/concept mapping, outlining, summaries, synthesizers, advance organizers, etc.

Meta-Cognitive Strategies
Meta-cognitive strategies are strategies learners use to observe, plan, monitor, and regulate their own learning. It includes but not limits to self-planning, monitoring, and revising techniques.

The mental process and structures, including perception, thinking, language, and reasoning are central to individuals' attention, memory, and concept formation, making it more suitable to explain complex forms of learning in comparison to behaviorism (Nathan & Sawyer, 2022). Cognitivism can better explain the learning of structured complex knowledge that can be analyzed, decomposed, and standardized into a **rule-based or algorithmic system**. For example, in order to learn cost-benefit analysis, a learner could progressively master the sub-task of cost-benefit analysis (e.g., allocation of sum, buy/no-buy decision making, cost prioritizing, and so on) and assemble each sub-task for completing a cost-benefit analysis for a development project.

Cognitivist instruction stresses processing strategies that aim to communicate or transfer knowledge most efficiently and effectively as possible (Danish & Gresalfi, 2018; Ertmer & Newby, 2013; Wilson & Myers, 2000). **Structured instructional components, learners' prior knowledge** and **learning strategies** to approach learning and prevent forgetting, and **learning motivation** are the key factors that account for learning. The cognitivist instructional design practices include:

- **Task/knowledge analysis** to identify and illustrate the prerequisite relationships which results in hierarchical structures of knowledge which results in hierarchical structures of learning content and decomposition of instruction;
- **Learner analysis** to determine learners' predisposition to learning (i.e., how do learners activate, maintain, and direct their learning) and to bridge between learners' prior knowledge and the target learning;
- **Design of information bridge** to facilitate recall of prerequisite skill and draw analogies between prior knowledge and target knowledge;
- **Information elaboration and chunking** that structure, organize, and sequence information to facilitate optimal processing;
- **Design of practice and assessment** to provide informative feedback that directs student's information processing, self-regulated learning, and knowledge transfer;
- **Design of learning environment** that actively involves learners in the learning process and supports learners' self-regulated learning and motivation maintenance.

However, cognitivism falls short of explaining the phenomenon that learners achieve different learning outcomes even with adaptive information bridging instruction. It also has its limitation in explaining learning with a holistic view of knowledge dependent on cultural and physical context. For example, when a novice instructional design student learns to design, develop, and implement need assessment. Cognitivism is sufficient to explain the learning of what need assessment is and how need assessment is designed, developed, and implemented. But it is not sufficient to explain that student should also develop their **personal understanding** of needs assessment and the **social-cultural context's impact** (e.g., the testing culture with value judgment influencing people's honesty on needs) which may only be identified within a specific context.

When considering the learner-centered approach to complex learning (i.e., learning and the meaning of knowledge vary across contexts and cases), instructional designers should be aware of the limitation of cognitivism and emphasize that each learner is a unique constructive learning agent instead of a computer-like information processor.

Constructivism

Constructivism denies that the human mind can have a 1-on-1 mapping to an absolute-objective external world. Knowledge always emerges in contexts and is constructed from authentic real-world experiences with personal meanings for each learner (Ertmer & Newby, 2013). Therefore, from behaviorism and cognitivism to constructivism, it represents a paradigm shift with attention directed to learners' knowledge construction process through reflection, experience, and meaning making.

Learning is a process in which learners flexibly use prior knowledge from diverse sources to interpret the actual experiences and create novel and situation-specific understanding as meaningful "schema" (Nathan & Sawyer, 2022). Learning is the result of active interactions with the external world with reflection, adaptation, and modification instead of transferring intact knowledge structure from the external world into memory as proposed by behaviorism and cognitivism (Ertmer & Newby, 2013). Therefore, learners' schema is constantly open to change based on learner's current and changing understanding of the external world.

Regarding the question - *"How do learners interact with the external environment to create meaning and construct knowledge?"*, constructivism is typically divided into (Powell & Kalina, n.d.):

- **Cognitive constructivism:** Knowledge is constructed in the process of assimilation and accommodation through searching for balance in the cognitive conflict. The cognitive conflict is resolved through inquiry and experimental processes with active reflection, such as inquiry-based learning. Learning is a personal process in which thoughts precede language to interpret the real-world experience and process new information to fit into what is already in memory. Learners' prior knowledge and cognitive ability set the boundaries of how learners make sense of new experiences and concepts;

Assimilation
Assimilation refers to the process of brining in new knowledge to the existing schemas.

Accommodation
Accommodation refers to the process of modifying the existing schemas to accommodate the new information or knowledge.

Cognitive Conflict
Cognitive conflict refers to the differences between encountered experiences and presented information.

- **Social constructivism:** Knowledge construction is mediated by social interaction, including the use of language and meaning negotiation with active reflection. Language (including inner speech) is part of the integral process of learning and thinking, which impact how learning happens. During social interaction and culturally organized activities, **more knowledgeable others** can scaffold learners' learning in the **Zone of Proximal Development (ZDP)**, to assist learners to attain cognitive growth that could not achieve individually.

Zone of Proximal Development (ZDP)
Zone of Proximal Development (ZDP) is a zone where learning could occur with learners' individual efforts
and the assistance of more knowledgeable others.

In contemporary instruction, learning is often viewed and understood as happening through an interweaving of learning described by both cognitive and social constructivism. An example would be an activity where a student works on the assignment with aid from more knowledgeable others (i.e., teachers or more advanced peers). This incorporates the cognitive constructivist notion that students act first on what they can do on their own as well as the social constructivist notion that when they don't succeed, with assistance from the teacher (or peers), they learn the new concept. Based on what they learned, in the future, learners will also be able to do that individually.

Knowledge acquisition can be divided into three phases: introductory, advanced, and expert (Steffe & Gale, 2012). In the introductory phase, knowledge is relatively structured, simplified, and standardized which is presented for learners to understand and be aware of the key concepts and facts in a domain. For example, when teaching basic physical science principles that are orderly and regular in the abstract and textbook applications, instruction from behaviorist and cognitivist perspectives has proven effective.

In the advanced phase, knowledge involves **concept-and case-complexity** and **cross-case irregularity** (Steffe & Gale, 2012). For example, the application of well-structured physics concepts to real-world cases usually involves the consideration of multiple concepts and principles (e.g., well-structured physics principles, features of the terrain, climate, available materials, cost, etc.) and their interactions, which leads to the development of solutions to the problem. The acquisition and construction of advanced knowledge require learners to constantly develop conceptual meanings of these multiple concepts and principles from case to case.

Concept-and case complexity
Concept-and case complexity refers to the construct of concepts and cases involves multiple schemas and principles and a variety of conceptual interaction.

Cross-case irregularity
Cross-case irregularity refers to phenomenon that the pattern of conceptual interaction varies across cases.

With the epistemological assumptions that knowledge and learning are dependent on the content and the context of learning, and that learned knowledge is constantly changing, constructivism is more suitable to address **individual differences in learning** and learning that involves **advanced and ill-structured knowledge domains** instead of the relatively structured knowledge.

Constructivist instruction stresses learners' long-term mastery of domain knowledge complexity and across-case diversity, which moves learners progressively toward what an expert user of that domain might think (Ertmer and Newby, 2013; Wilson and Myers, 2000). **Learners, knowledge, social and physical context, activities**, and their **interactions** (i.e., learners' learning experiences in the learning environment) are critical in instruction to support target learning. Constructivist instructional design practices include:

- **Task/knowledge and context analysis** to identify contexts in which the knowledge and skills will be learned and subsequently applied;
- **Learner analysis** to identify the necessary support on knowledge construction processes based on learners' capability to process information and their problem-solving skills;
- **Presentation of information in different ways** that facilitate understanding of knowledge complexity and across-case diversity, including revisiting content at different times, in rearranged contexts, for different purposes, and from different conceptual perspectives;
- **Provision of guidance and scaffolding** that scaffolds learners learning and provides guidance for learners to construct the knowledge in their ZPD;
- **Design of practice situation** that supports learners' problem-solving skills, including developing pattern-recognition skills, modeling, and coaching student toward expert performance, and presenting alternative ways of representing problems;
- **Design of assessment** that focuses on the transfer of knowledge and skills;
- **Design of learning environment** that provides authentic, relevant contexts that can be experienced with multiple perspectives, social negotiation, reflective awareness, and considerable guidance.

Sociocultural learning

Sociocultural learning goes beyond the "individual cognitive" perspectives, defining knowledge as situated practices and social understanding of world structures and how they constrain and guide individual behavior (Wilson and Myers, 1999). Knowledge is embedded and distributed in a variety of actions, activities, and cognitive artifacts (i.e., materials tools, symbol systems, and human beings) that are created within a specific historical timescale in a social community.

Learning happens when learners actively participate in a **Community of Practices (CoP)**, develop generative **social practices** with **cognitive artifacts**, and develop **identities** within and beyond the learning community (Parker & Goicoechea, 2009). Learning continuously happens when novices interact with the experts, cognitive artifacts, rules, and norms within the community. Learning results in enduring social practices that allow continuous development without a strict requirement of instruction (Wilson & Myers, 2000).

Materials Tools
Materials tools refers to tools used to mediate the psychological processes, which later get internalized to function inside the individual withou being physically present, such as, picture card, concept map, visual models, etc.

Symbol Systems
Symbol system refers to the system individual used to mediate the psycologial process, such as language, mathematic sysbom, etc.

Learning Community
Learning community refers to a group of people who share common academic goals and attitudes and collaborate with each others to develop domain-specific expertise.

An example is a mathematics course for master's degree study. The community participants (i.e., students, teachers, mathematics researchers), and physical classroom settings (a mathematic research group sites) form a learning community. Students are guided to learn mathematics knowledge through solving authentic real-world problems with cognitive artifacts, such as textbooks, mathematic notation systems, authentic real-world problems, etc. During learning, students are encouraged to actively engage in problem-solving practices, in which experts act as facilitators and co-participants. Students collaborate and engage in artifact-mediated activities, such as analyzing and discussing problems simulated on the computer, engaging in rich discourse with others (i.e., peers and experts), and articulating, reflecting, and confirming the solutions to the problems during the rich discourses.

Students could also interact with others beyond the current learning community via the internet. The learning community continues to be consolidated when both teachers and students develop their identities within the learning community, forming long-term relationships and increasing participation in CoP in both local and global mathematics communities (Esmonde, 2016).

Sociocultural learning is suited for collaborative learning contexts with ill-defined problems that do not have strict starting and ending points and/or assessment of the completion of instructional objectives. Due to the emphasis on learning as taking place in a dynamic, authentic, and complicated environment, sociocultural learning is commonly used to explain informal learning, e.g., workplace learning, but it is important to realize that structures within formal education could also be viewed from this perspective. Sociocultural learning emphasizes that the social and cultural factors within the community significantly impact learners' learning experiences and alter learning outcomes. Thus, it plays an essential role in guiding instructional designers to develop instructions and learning communities that fit into local, global, and cultural reality.

Sociocultural learning emphasizes that instruction should (1) create a learning community that situates the instruction, and (2) bridge formal and informal learning to facilitate learners' long-term development in realistic settings. The key factor accounting for learning is **the authentic, inclusive, and socially formed learning community** that is fulfilled with artifacts, artifact-mediated activities, discipline-specific systems of notation, social agents, and real-world physical environments (Wilson & Myers, 2000). The sociocultural instructional design practices include (Eun, 2010):

- **Bridge the formal and informal learning** that integrates knowledge and experiences from informal everyday learning with the verbal formal knowledge in instructional settings;
- **Design authentic learning environments** with realistic settings with diverse cognitive artifacts to support learners to connect learning to real-world situations from the past, future, and other parts of the world;
- **Design an inclusive learning community** that is fulfilled with interactive, collaborative, dynamic, and dialogical learning. Students feel safe to express their personal experiences relevant to the target learning and to engage in collaborative activities with shared goals and purposes that are constantly negotiated through dialogues;
- **Provision of communities of practices (CoP)** that learners and teachers coparticipant in problem-solving practices or inquiry-based activities that serve to solve the real-life problem with a variety of mediated artifacts. Interactions between novices and experts are developed to make tacit and inert expert knowledge more explicit, which allows learners to actively reflect on and take up, or even challenge and create social norms and practices. Students develop their identities through internalizing and generating social practices and products.

Using sociocultural learning to guide the systematic instructional design can sometimes be challenging due to the different nature of "instruction" and "participatory/informal learning" and the time and resources for setting up realistic settings. It may also be more difficult to formulate clear learning objectives, as the learning outcomes may vary along with the socio-cultural interactions that take place within the learning environment. However, it does not mean instructional designers should abandon this perspective to guide instructional design. Instead, instructional designers should consider it as guidance to use a holistic approach to develop learning communities for "instruction" and make logical connections between diverse kinds of elements within the learning environment. However, instructional designers should be aware that instructors (teachers or any instruction deliverers) and learners develop and maintain learning communities. Instructional designers mainly attempt to provide guidelines for developing a learning community and ensure the required resources or access to the resources are provided for the community.

Self-regulated learning and external regulation

Multiple perspectives on learning and their implication on instruction indicate the dynamic relationships between instruction and learning, which is also central to the dynamic relationship between external regulation (instructional practices) and learners' self-regulated learning. **Self-regulated learning** explains learners' initiative in acquiring knowledge and participating in the community of practices. Learners plan, monitor, control, and reflect on their cognition, **behavior**, **motivation**, and **emotion** within learning tasks for reaching the goal or reaching forward by planning for future tasks (Winne & Azevedo, 2022). **External regulation** refers to any instructional practices that impact and guide learners' learning process, embedded in **learning materials**, **learning activities**, **instructional guidance**, and **assessments**. Learners' self-regulated learning and external regulation interweave and mutually impact the learning processes, which appear in but are not limited to the following aspects (Winne & Azevedo, 2022):

- **Learning objectives and planning:** Learning objectives define the "ought" learning goals as external regulations that impact how learners identify what should be learned and reflect their strengths and limitations in achieving the learning goals. Learners might have their personal learning objectives when they engage in different learning activities;
- **Instructional guidance and controlling:** Learners constantly regulate their actions, strategies, and motivation when they engage in learning activities to reach their learning objectives. Instructional guidance inserts external regulation that could regulate learners' self-regulated practices, or learners' understanding, actions, and practice to reach the learning objectives;

Cognition
Cognition refers to the learning style cognitive learning strategies, metacognitive and regulation strategies, resources management strategies, etc.

- **Learning assessment, monitoring, and reflecting:** Learners typically regulate their learning within and outside of instructional settings based on their understanding of the criteria and function of assessments. Formative assessment could exert external regulation for learners to monitor and reflect on their learning progress, which leads to the control and regulation of their learning in subsequent learning activities. Summative assessment could be used for learners to identify how well they have achieved the learning objectives and plan for the future study;

Formative Assessment
Formative assessment refers to the assessment implemented during the learning process to provide ongoing constructive feedback to monitor student learning.

Summative Assessment
Summative assessment refers to the assessment implemented at the end of the instruction to evaluate students' learning achievement against specific standards or criteria.

Taking self-regulated learning into account during instruction design is the acknowledgment of learners as the center of learning who take control of their own learning (Winne & Azevedo, 2022). The interweaving of self-regulated learning and external regulation shed light on two concrete instructional practices: (1) provide meta-cognitive strategies or explicit instruction on self-regulated learning as external regulation for learners, and (2) provides support and scaffolding for learners to achieve the learning goals when they don't have sufficient ability to self-regulate their learning.

External regulations should be provided based on learners' needs. When learners' needs are satisfied and the learning environment allows students to be immersed in the learning activities, learners go beyond the first confronted learning objectives and exhibit preferences for challenges and risk-taking (Paris & Paris, 2001). However, learners vary in their ability to define ongoing and upcoming activities in the light of their own needs, expectancies, and ability to regulate behaviors to protect their own and instructional goals. Understanding this dynamic helps to understand why the same learning environment may be perceived as too structured and restrictive by some learners and too unstructured and open by others.

Instructional designers should, therefore, on the one hand, design the external regulation that provides sufficient guidance on the learning practices, but on the other take care that this does not undermine the development of self-regulation capabilities. It reveals the responsibility of instructional designers to design instructions that promote independent, strategic, and effortful learning (Paris & Paris, 2001). In order to find an appropriate balance, learner persona information becomes essential in informing instructional design to develop functional instruction with a user-centered approach.

Instructional design theories

Instructional design theories provide guidelines for designing the instructional system that supports specific kinds of learning. They have situational, componential , and probabilistic characteristics (Reigeluth, 1999). In other words, instructional design theories provide the guidelines for designing instruction but they could not guarantee the effectiveness of instruction without considering the design contexts. Therefore, instructional designers should identify the values that underlie the pursued goal (which is usually based on learning theories) and the instructional solutions develop to attain those goals. Meanwhile, through implementing and testing the designed instruction, instructional designers continue to develop instructional design theories based on empirical evidence and real-life experiences. Such a process indicates that instructional designers develop their expertise through active reflection on the interaction of learning theories and instructional design theories.

Situational
Instructional design theories indicate what instructional methods should and should not be used for the specific types of learning, and when and when not to use them regarding the instructional context (i.e., learning objectives, learner persona, and learning environment).

Componential
Instructional design theories provide a series of rules, sub-rules, and metarules for employing instructional strategies to teach different kinds of subject-matter content in different settings.

Probabilistic
Instructional design theories are developed based on theoretical and empirical testing of the effectiveness of instruction for specific types of learning in different instructional settings. The effectiveness of instruction also depends on instructional contexts, learners, and instructors.

The following instructional design theories indicate the systematic design guidelines for designing instructional events, learning activities, instructional materials, learning environments, and learning communities for different types of learning.

Gagné's 9 Events of Instruction and Mastery learning

Gagné's condition of learning theory takes the cognitivist perspective. It focuses on the instructional events that facilitate information organizing, analyzing, memorizing, and retrieving (Kurt, 2021) (see Figure 2). Nine events of instruction are designed to facilitate learning engagement and assist learners to achieve learning objectives for learning in small units. For detailed information on Gagné's nine events of instruction check the link:

https://educationaltechnology.net/gagnes-nine-events-of-instruction/

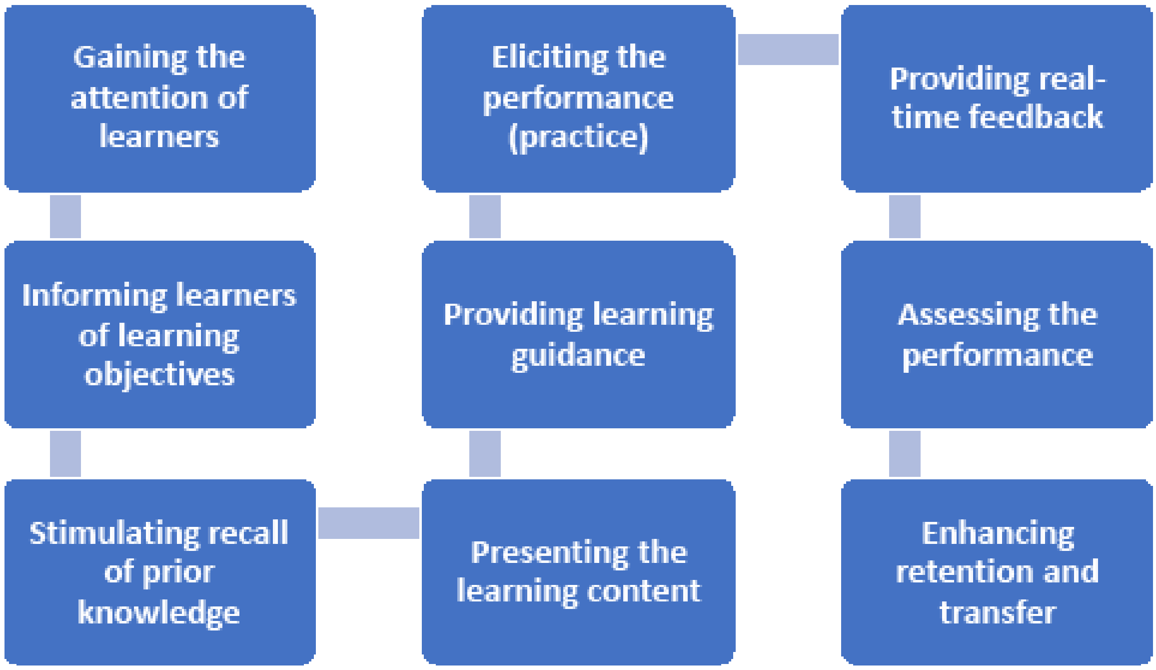

Figure 2 Gagné's 9 Events of Instruction

Gagné's nine events of instruction provide a straightforward method to design lessons that takes an instructional time of hours. It can also be used iteratively to develop a series of lessons that takes instructional time for a short period. **Technologies assist in instructional practices and learning activities, such as (1) developing multimedia learning materials to gain learners' attention or present the learning content and (2) developing digital real-time quizzes (e.g., Kahoot!) to simulate recall of prior knowledge or provide real-time feedback**. For cases of using Gagne's nine events of instruction see Case 1: **nursing course** and Case 2: **teaching psychomotor skills.**

Mastery learning is another instructional method that follows a similar instructional sequence but emphasizes that some learners should be allowed additional time to understand the content or develop a particular skill at their own pace (see Figure 2) For detailed information on Mastery learning check the link: **https://research.com/education/what-is-mastery-learning**

Multimedia Learning Materials
Multimedia learning materials refers to the learning materials include text, including written texts and narration, and picture, including static pictures or dynamic picture like videos.

Figure 3 Mastery learning

To design based on Gagné's nine events of instruction or mastery learning, instructional designers are required to take the instructional design practices stemming from cognitivism, including task/knowledge analysis, learner analysis, design of information bridge, design of practices and assessment, and design of learning environment. **Technologies assist in instructional design practices, such as (1) visualizing the knowledge and task analysis with diagrams and (2) using digital storyboards to visualize the instruction events in Word or PowerPoint.**

However, just as cognitivism is limited in explaining complex learning of ill-structured domains, these two theories are not suitable for complex learning that involves a holistic understanding of multiple knowledge, skills, and attitudes or solving complex problems.

Cognitive load theories - Theory of multimedia learning and 4C/ID ten steps to complex learning

When encountering new learning material, learners are engaged in a process of interpreting, analyzing, organizing, and synthesizing the new information for future use. Taking cognitivist perspectives on learning, cognitive load theory (CLT) stipulates that human working memory has a limited capacity to hold and process information elements and the element interactivity simultaneously (Sweller et al., 2019). In this process, cognitive load is induced by learning materials and learning activities, which could be categorized into intrinsic cognitive load and extraneous cognitive load (Kalyuga, 2011):

- **Intrinsic cognitive load** trefers to the load induced by the complexity of subject-matter knowledge and the essential cognitive processing of essential information (Sweller et al., 2019). Low interactivity material contains a single element or a small number of elements that can be learned independently, whereas high interactivity material consists of interdependent elements that can only be well understood in relation to each other;

- **Extraneous cognitive load** refers to the load induced by the irrelevant information in the learning materials which hinders learners' cognitive processing of new information (Sweller et al., 2019). High extraneous cognitive load may be caused by (1) content beyond the learning scope in learning material, (2) irrelevant information in presentations that distracts learners' attention from essential information, or (3) learning activities that require extra cognitive resources for learners to process the essential information.

Intrinsic cognitive load is indispensable for learning while the extraneous cognitive load is caused by the poor design of instruction. Learning tasks that induce **cognitive overload** or induce extraneous cognitive load may hinder learners' learning performance. Instructional designers should manage the intrinsic cognitive load or reduce the extraneous cognitive load. However, whether the learning tasks are appropriately designed is closely related to the learners' expertise level (Kirschner, 2002). The **expertise reversal effect** indicates that design principles that are effective for novice learners may not be effective or even hinder learning for more knowledgeable learners (Kalyuga, 2021). The explanation is that once learners construct a schema based on the information and store it in long-term memory, the schema only takes up space for one element in working memory (Sweller et al., 2019). Learners with higher expertise levels have more space in working memory spared for information processing compared to learners with lower expertise levels. It also explains why sometimes the same instruction might pose too much cognitive load for some learners but might be too simple for some others, or the necessary information as the intrinsic cognitive load for lower-expertise students (e.g., instructional signaling) might become irrelevant information as the extraneous cognitive load for higher-expertise students. In addition, learning usually happens in a complex situation where learners may also develop various ways to avoid instantaneous overload, such as expanding the learning time or using other technology like a notepad to offload working memory (de Jong, 2010).

Therefore, it implies that instructional designers do not only consider lowering the cognitive load in general but also maintaining intrinsic cognitive load in a manner that learning tasks are challenging enough for students to actively engage in learning with sufficient instructional support (Sweller et al., 2019). Instruction design principles stemming from cognitive load theory aim to (1) design learning materials and activities that induce cognitive load within the learners' working memory capacity limit, (2) design instruction to facilitate the cognitive process of coding multiple elements of information as one cognitive schema, and (3) design learning practice that facilitate learners to automate rules to offload working memory (Kirschner, 2002)

Instructional designers utilize cognitive load theory to manage the interaction among learning material, learning activities, and learners. **Theory of Multimedia Learning** and **4C/ID Ten Steps to Complex Learning** are developed based on the integration of cognitive load theory and other learning theories to provide extensive guidelines for designing learning materials and learning tasks.

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Theory of multimedia learning focuses on the design of multimedia learning materials based on how the human mind works to promote meaningful learning (Mayer, 2021). It introduces four groups of principles for designing multimedia learning (For detailed analysis and application of design principles within contexts see **The Cambridge Handbook of Multimedia Learning):**

- **Principles for reducing extraneous information processing (extraneous cognitive load):** Reducing the need of processing irrelevant information in learning materials with coherence principle, signaling principle, redundancy principle, and spatial contiguity principle, so that learning material frees learners' cognitive resources to engage in sensemaking of essential information (Fiorella & Mayer, 2021d);

Coherence Principle
Coherence principle indicates that the inclusion of seductive details information in learning material should not over attract learners' attention away from the essential information.

Signaling Principle
Signaling principle indicates that learning materials should include instructional cue that direct students' attention to key information, highlight the organization of the lesson and foster approprpiate connections between words and graphic.

Redundancy Principle
Redundancy principle indicates that the inclusion of redundant modalities information, such as on-screen text identical to the narration, should consider learners' learning needs and expertise level.

Spatial Contiguity Principle
Spatial contiguity principle indicates that the Inclusion of graphics should be physically integrated with the text.

Principles for managing essential cognitive processing (intrinsic cognitive load): Facilitating learners' cognitive processing of the essential information (element interactivity of the learning materials) segmenting principle, pre-training principle, and modality principles so that learning materials support learners to achieve learning objectives (Fiorella & Mayer, 2021c);

Segmenting Principle
Segmenting principles refers to the segmenting of learning material presentation into meaningful sections, which allow students to control when to go on to the next segment of a presentation.

Pre-training Principle
Pre-training principle refers to provide instruction support that equip student with knowledge to make it easier to process essential learning material.

Modality Principles
Modality principles refers to the practices of replacing one modality of information, such as written text, with another concurrent modality of information like narration to free learners cognitive resources.

Principles based on social and affective features: Incorporating social and affective cues with personalization principle, voice principle, and embodiment principle, so that learning materials foster student motivation and meaningful learning. It (Fiorella & Mayer, 2021b);

Personalization Principle
Personalization principle refers to the design of learning materials are presented in a conversational or polite style, rather than a formal or direct style.

Voice Principle
Voice principle refers to the design of learning material should be presented in a human voice rather than computer-generated voice.

Embodiment Principle
Embodiment principle refers to the design of learning material that include the instructor or onscreen pedagogical agents who engages in human-like movement, such as using gestures, eye-contact, or facial expression.

Principles based on generative activities: Designing learning materials that foster the self-regulated feedback principle, learner control principle, and cognitive load self-management principle, and facilitate generative processes with visualizing activities, verbalizing activities, and enacting activities to support learners to select, organize, and integrate the learning material (Fiorella & Mayer, 2021a).

Feedback Principle
Instruction should provide both explanatory feedback and corrective feedback for learners to monitor their learning.

Learner Control Principle
Instruction should balance the learners control and instruction control on learning activity, learning pace, information display, and so on, which affect the effectiveness of the instruction and whether other design principle works or not in the given situation.

Cognitive Load Self-Management Principle
Instruction could teach students to apply CLT principle themselves to manage their own cognitive load in order to learn from poor-design materials.

Visualizing Activities
Visualizing activities includes learning by drawing that creating a pictorial representation of physical characteristics of learning materials, learning by mapping that create visuospatial representations depicting abstract conceptual, and learning by imagining that generate internal image to depict the content of the lesson, such as the structures of a physical system or the steps in a procedure.

Verbalizing Activities
Verbalizing activities include learning by summarizing the main ideas from a lesson in one's own words; learning by self-explaining that generate verbal statements to clarify the meaning of learning material; learning by teaching that construct deeper understanding of the learning material by explaining it to others.

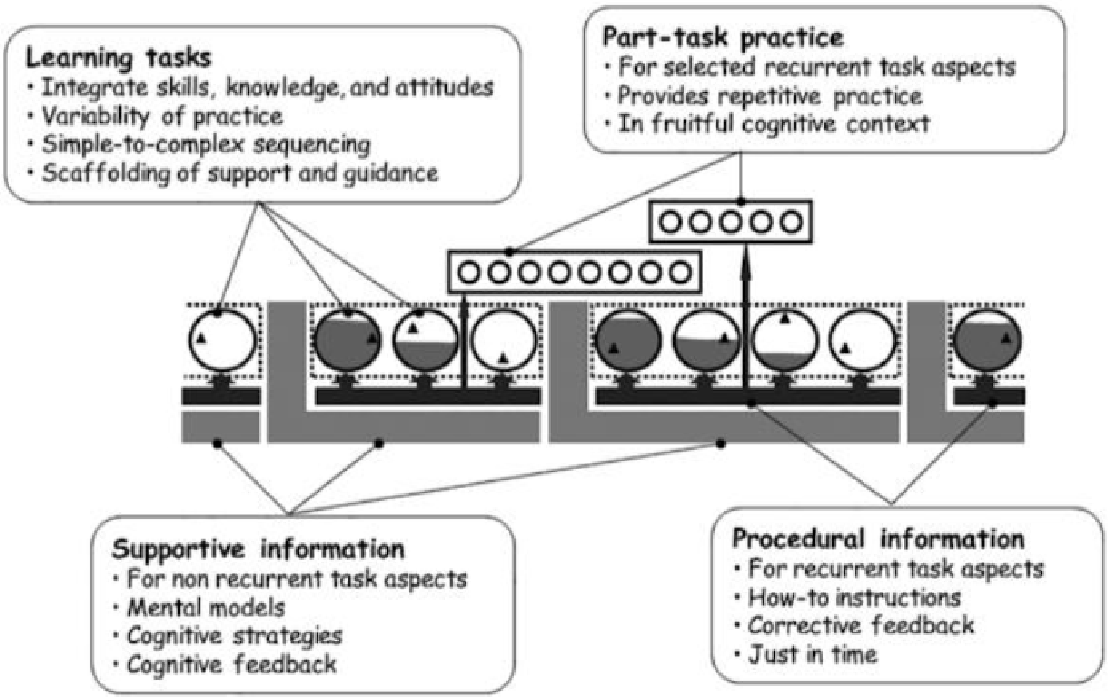
Enacting Activities
Enacting activities includes learning by gesturing that use one's hands to represent abstract concepts or problem-solving strategies and learning by manipulating objectives that manipulate physical or virtual objects to present the learning material.

The four groups of design principles illustrate that effective learning depends on the interactions between learners' characteristics, the **learning material** (e.g., the nature of learning and knowledge), and **learning activities**. For instance, the signaling principle could be necessary for designing learning material for lower-expertise students but might be unnecessary for higher-expertise students. Instructional designers do not take these design principles as the "golden rules" to design instruction but utilize these principles to provide appropriate instructional support and to ensure students have sufficient background knowledge and metacognitive skill to learn. It is a process for instructional designers to continuously develop the expertise from real-world instructional design practices to utilize the design principles within contexts. Please read through the **common but questionable principles of multimedia learning.**

Learners' Characteristics
Learners' characteristics refers to learners' existing learning habits, and strategic knowledge, as well as beliefs about themselves.

4C/ID Ten Steps to Complex Learning takes cognitivist and constructivist perspectives. It provides guidelines for managing the cognitive load induced by the instruction for complex learning. Complex learning typically involves high element-interactivity learning material and learning with (1) a set of learning goals that integrate complex knowledge, conceptual and procedural skills within and attitudes towards specific subject domains, and (2) the need to apply knowledge to other novel contexts that are different from the learning contexts (Merriënboer & Kirschner, 2017). This kind of complex learning has a relatively long instructional time (from weeks, months, to years).

4C/ID indicates that environments for complex learning can always be described in terms of four interrelated components which are commonly supported by different multimedia materials (Merriënboer & Kirschner, 2017):



- **Learning tasks:** Learning tasks integrate the target set of knowledge, skills, and attitudes. Within the whole learning task, sub-tasks are sequenced from simple to complex with supportive information that helps learners construct cognitive schemas in a process of inductive learning from concrete, authentic, and whole-task experience. **Technology, such as computer-based simulation, could simulate the task environment that is safe for learners to make errors and free of extraneous irrelevant stimuli (For the example of using simulation for complex learning see case: high-fidelity simulation-based training)**

- **Supportive information:** Supportive information, such as textbooks, elaborates on to-be-learned content in a manner that supports learners to integrate the new information with prior knowledge. It can be mental models, cognitive strategies, and cognitive feedback. **Technology, such as computer-based hypermedia and multimedia systems, could assist in the design of interactive supportive information;**

Mental Models
Supportive information refers to declarative representation of how the world is organised containing both general, abstract knowledge and concrete cases that exemplify this knowledge.

Cognitive Strategies
Cognitive strategies refers to the description of the successive phases in a problem-solving process and the rules of thumb or heuristics that may be helpful to successfully complete each of the problem-solving phase.

Cognitive Feedback
Cognitive feedback refers to feedback regarding the quality of performance to promote schema construction and to stimulate learners to reflect on the quality of their personal problem-solving processes.

- **Part-task Practices:** Part-task practices consist of the selected recurrent constituent skills of the complex skills. The recurrent constituent skills are algorithmically described in terms of rules (i.e., routine aspects of behaviors). Part-task practices assist learners to automate the routine aspect of behavior, which offloads working memory for the nonrecurrent aspects of learning tasks. **Digital game-based practices, Quizlet for small exercises, or simulation for practicing perceptual-motor skills, could be used to design part-task practices;**

- **Procedural information (Just-in-time information):** Procedural information provides the prerequisite information for performing part-task practices. It demonstrates or provides instances of part-task practices, which are commonly organized in small units to prevent cognitive overload. **Smartphones and tablets can provide augmented reality, video, or responsive screens to present procedural information.**

Learning tasks and supportive information support inductive learning from the whole task and elaboration. Part-task practices and procedural information support schema automation and rule formation. Instructional designers to integrate these four components in a complex learning environment with the following ten steps (Merriënboer & Kirschner, 2017): (1) **Design learning task**, (2) **Design performance assessment**, (3) **Sequence learning task**, (4) **Design supportive information**, (5) **Analyze cognitive strategies**, (6) **Analyze mental model**, (7) **Design procedural information**, (8) **Analyze cognitive rules**, (9) **Analyze prerequisite knowledge**, (10) **Design part-task practice**. (For detailed design steps see **Ten Steps to Complex Learning**; for the case using 4C/ID to design instruction see **designing teacher professional development program)**

Cognitive Apprenticeship

Cognitive apprenticeship is developed based on the constructivist perspective on learning and sociocultural learning theory. It adopts the apprenticeship approach that learners learn by observing experts' thinking processes and practicing the skills under the guidance of experts in a learning community (Collins & Kapur, 2022).

Cognitive apprenticeship emphasizes the design of the learning environment that facilitates learners to participate in the community of practices and construct knowledge through artifact-meditated activities (Collins et al., 1991). It provides heuristic guidelines for setting up a learning environment and developing a learning community for long-term complex learning:

- **Learning content:** Learning content is divided into domain knowledge, heuristic strategies, control strategies, and learning strategies. Domain knowledge is the foundation for the development of strategies knowledge. The strategies knowledge underlies an individual's ability to apply domain knowledge and solve problems. Instructional designers analyze the types of knowledge required for expertise development and determine the scope of learning.

Domain Knowledge
Domain knowledge refers to the explicit concepts, facts, and procedures associated with a specialized area. This is the type of knowledge that is generally found in school textbooks, lectures, and demonstrations.

Heuristic Strategies
Heuristic strategies refers to effective techniques and approaches for accomplishing tasks. But they do not always work, but in most cases they do, and they are simple and easy to apply.

Control Strategies
Control strategies refers to strategies of carrying out a task and making decision about how to proceed in a task depend on an assessment of one's current goals, difficulties, and strategies available for dealing with difficulties.

Learning Strategies
Learning strategies refers to the knowledge for learning all of domain knowledge, heuristic strategies, and control strategies. It is strategies about how to learn ranges from general strategies for exploring a new domain to more specific strategies for extending or reconfiguring knowledge in solving problems or carrying out complex tasks.

- **Instructional methods:** Instructional designers select instructional methods for modeling, coaching , and scaffolding to make tacit expert strategies knowledge visible to learners and support learners to progressively develop abilities to conduct performance tasks independently (Collins et al., 1991). In this process, learning activities like articulation, creation, and reflection are integrated to help students gain conscious access to and control of their own problem-solving process.

Modeling
The expert in the community will demonstrate how to complete a task and explicitly articulate the rationale of the task procedures. The novices, students, could observe experts' performance and learn through the explicit demonstration and articulation.

Coaching
While the novice practice, the expert provides hints, feedback, or reminders to bring novices' performance closer to the experts' performance.

Scaffolding
The more knowledgeable others provide support for the novice when they perform the task within their zone of proximal development until the students master the task. The support from more knowledgeable other gradually fades out when students get more and more familiar with the practices.

Articulation
Student articulate their knowledge, reasoning, or problem-solving processes in a domain during the learning and practice process. This enable tacit knowledge to be made explicit.

Creation
Students attempts to solve the problems, perform the learning tasks, and create tangible or virtual learning products by utilizing the learned knowledge.

Reflection
Novice reflect and analyze their performance that enable abstractions to be formed. Through comparing their own problem-solving processes with those of an expert, other students, the novice develop an internal cognitive model of expertise.

- **Learning activities and materials:** Learning activities and learning materials should be designed in a manner that structures students' learning as well as preserve the meaningfulness of the whole task. It follows the three main principles: (1) Global skills are presented before local skills to encourage students to build up a conceptual model of the target learning; (2) **Instruction gradually increases the complexity of learning tasks** that allows students to learn in their ZDP; (3) **Instruction gradually increase case diversity** that allows learners to distinguish the authentic and concrete conditions under which they do and do not apply the domain and strategies knowledge.

Global skills are presented before local skills
Instruction provides the general idea or overall conceptual structure of knowledge body for students to make sense of the more detailed knowledge and skills.

- **Sociology of the learning environment:** The sociology of the learning environment includes authentic contexts and the diverse humanistic (e.g., learners' motivation and confidence) and social-cultural factors in the learning community. The learning environment should provide (1) **situated learning in diverse authentic contexts** that promote learning both tied to the contexts regarding its uses and independent of any particular context through cognitive differentiation, and (2) **artifact-mediated activities** that require learners to engage in collaborative learning with rich discourse practices when exploring solutions to the authentic problems.

Technology could be used to support instructional design practices such as using PowerPoint to visualize the scope of learning content or using digital storyboards to visualize the structured part of instruction. Technology can also be used to support instructional practices. For example, social media or online forum provides a social context that enables students to present findings, interview, discuss and debate the issues. Virtual working space, multiple resources from the internet, and tools for creating multimedia materials could be provided as cognitive artifacts. Simulation in computers, smartphones, or tablets can support the modeling and provide realistic contexts.

Cognitive apprenticeship emphasizes both the structured instruction for learners to master experts' skills and the development of a learning community that allows unstructured learning, informal learning experience, and the development of self-regulated learning ability. For the example of using cognitive apprenticeship to design instruction **see Cognitive apprenticeship - making thinking visible.**

Elaboration theory

Elaboration theory provides guidelines for scoping and sequencing the subject-matter content that involves more than one topic (Reigeluth, 1999). The included topics are interrelated (Reigeluth, 1999). Elaboration theory is suitable for complex learning content that aims to (1) **develop domain expertise for understanding complex cognitive structure** (i.e., a body of subject matter such as economics), and (2) **develop task expertise in performing complex cognitive tasks** (i.e., a specific complex task such as managing a project). Respectively, two main elaboration models are provided for guiding the presentation of learning materials to learners (Reigeluth, 1999):

Topic
A topic could be a concept, a principle, or a performance task which can be organized based on its definition, instances, and practices.

- **Domain-elaboration sequence is** used for elaborating two main kinds of knowledge: conceptual knowledge (i.e., concept and concept map for understanding "what") and theoretical knowledge (i.e., principles and causal models for understanding "why").
    - **Conceptual elaboration sequence** concerns the inclusivity among concepts with respect to either parts or kinds. Instruction starts with the broadest concepts (e.g., music) and continues with more narrow and detailed concepts (e.g., medieval music, classical music, romantic music, etc.).
    - **Theoretical elaboration sequence** concerns the causal relationships or natural-process relationships among changes in concepts. Instruction starts with the broadest principles (e.g., the law of supply and demand) and continues with more detailed and complex principles (e.g., the changes of supply of, and demand for, something influences its price and vice versa).
- **Simplifying condition method (SCM)** is used for elaborating both **procedural task** that focuses on the mental and/or physical steps and **heuristic task** that focuses on principles, guidelines, and/or casual models to decide what to do. The instruction starts with the simplest version of real-world tasks that is still representative of the whole task and progressively engages learners in more complex versions of the tasks in different conditions. During the instruction, learners are presented or actively explore the **descriptions for all the objects** involved in the performance, the **goal** for each task, the **consideration** for reaching the goal, the **causal factors** for the consideration, the **guidelines and decision rules** used by experts, and the **explanations** for the guidelines.

The elaboration theory uses the first presented content as **cognitive scaffolding** to provide learners with cognitive structures to understand the more detailed and complicated content. The progressive learning process emphasizes **progressive differentiation** that enables learners to understand the complexity of the domain knowledge or the expert performance across various contexts and cases. To do so, instruction should always zoom out the detailed content that provides a bird's view of the holistic knowledge body for learners to understand in which context the more detailed knowledge is situated. In real life, complex learning usually involves both domain knowledge and performance tasks. The SCM and domain-elaboration sequences can be used simultaneously.

Moreover, complex learning involves expert performances that are difficult to elaborate explicitly without context. To provide effective elaboration, instructional designers collaborate with subject-matter experts (SMEs) to conduct conceptual analysis, theoretical analysis, and performance task analysis which produce a holistic overview of the learning content. **Concept map software, PowerPoint, and Word could visualize the knowledge structure, and the guideline for instructors to provide appropriate scaffolding. A learning management system (LMS) could be used to upload flexible learning modules and objects so that it allows learner-controlled content sequences and eliminates redundancy by keeping track of what has already been learned.**

Conceptual Analysis
The analysis of all the concepts and their inclusivity relationship within a learning scope, which result in a conceptual knowledge structure such a concept taxonomy.

Theoretical Analysis
Identify all the principles and their inclusivity/complexity relationships within a learning scope, which result in a theoretical structures that shows principles elaborating on other principles.

Performance Task Analysis
Identify the simplest version of the task and the progressively more complex versions of the task an experts has ever performance within a learning scope, which results in a series of performance tasks within more and more complex conditions that involves complex variables and interactions.

Divergent perspectives on learning and instructional design

In practice, instructional designers are confronted with the limited time and resources to make specific types of learning happen The perspectives (i.e., behaviorism, cognitivism, constructivism, and sociocultural learning) differ from each other in their epistemological assumptions of knowledge and learning, which implies that different instructional practices may be more effective to support a specific type of learning and that some may be more suitable in connection to certain **learning outcomes** than others. Instructional designers should utilize these perspectives on learning (Ertma & Newby, 2013, Phillips & Soltis, 2009; Säljö, 2009):

1. to identify the potential explanations or mechanisms for the targeted learning regarding the certain learning outcomes;
2. to examine and select appropriate instructional-design theories and instructional practices.

Understanding the interaction between learning theories and instructional design theories enables instructional designers to be cautious of the theoretical background, purposes, functions, and consequences of shared instructional design practices (Murtonen et al., 2017). For example, regarding the "setting up behavior learning objectives", the behaviorist perspective uses it to set up the learning environments focusing on stimulating the target behavior while the constructivist perspective uses it to develop instructional methods and assessments that could facilitate the cognitive process that underlies the behavior.

Instructional design theories commonly take more than one perspective. For example, 4C/ID for complex learning involves both the cognitivist perspective on practices for rule automation and the constructivist perspective on the whole task for concrete inductive learning experiences. It is because learning is a complex phenomenon, in which learners might engage in various types of learning within the instructional timespan. Although different perspectives on learning have different epistemological assumptions, they also share a common ground that could be understood from two main perspectives (Nathan and Sawyer, 2022):

Various Types of Learning
e.g., mastering perceptual or motor skills, understanding rules, concepts, and principles, mastering complex problem-solving skills, analyzing complex cases, developing identity, etc..

- **Elementary perspective and knowledge acquisition:** Learning is a self-regulating process of emergence in interactions with peers, teachers, and external materials. Instruction aims to facilitate knowledge acquisition via (1) **using strategically regulated repetition and practices with reliable and timely feedback,** (2) **managing cognitive demands while integrating across information sources,** (3) **engaging learners in the meaning and knowledge construction, and** (4) **increasing learner's metacognitive awareness;**

- **Systematic perspective that facilitates learning participation:** Learning is located in a system consisting of multiple learning objectives, contexts, and settings. Knowledge is grounded in experiences in the physical world and distributed among members of a group and cognitive artifacts, and social interaction within the participation structure (Nathan & Alibali, 2010). Instruction aims to facilitate learning participation through (1) **providing collaborative discourse and argumentation,** (2) **engaging learners in accessible forms of authentic disciplinary practices, and** (3) **designing guided inquiry- and project-based learning.**

These two perspectives provide a more holistic view of the complex learning phenomenon in real life. In contemporary learning settings, instruction commonly involves both perspectives but might emphasize one of them regarding the learning goals, which results in different instructional design approaches. For example, **Gagné's nine events of instruction** and **4C/ID ten steps to complex learning** are more suitable for learning that emphasizes elementary perspective and knowledge acquisition. **Cognitive apprenticeship** is more suitable for learning that emphasizes systematic perspective and learning participation. But all three instructional design theories involved both elementary and systematic perspectives to develop a completed instruction. For example, when designing the modeling and learning activities sequence in cognitive apprenticeship, elementary perspectives are taken to provide structured learning.

Instructional designers could take the **systematic design paradigm** by following the design guidelines from the selected instructional design theories. The **First principles of instruction** provide a more general guideline for designing basic elements of instruction which are commonly mentioned in other instructional design theories (Merrill, 2002):

- **Problem-centered tasks:** Instruction promotes learning by engaging learners in solving real-world problems;
- **Activation:** Instruction promotes learning by encouraging learners to recall relevant schema that can be used, modified, or tuned to enable learners to incorporate the new knowledge into their existing knowledge;
- **Demonstration:** Instruction promotes learning via consistent demonstration regarding the learning goals;
- **Application:** Instruction promotes learning by aligning the application (practices) and assessments with the stated or implied learning objectives;
- **Integration:** Instruction promotes learning by giving learners the opportunity to publicly demonstrate their new knowledge or skills.

During the design process, instructional designers also take the **situational design paradigm** to choose different instructional design practices regarding the learning content, learners, and learning environment within each procedural step of systematic guidelines.

Instructional design as a complex system

Instructional Design as a Complex System

Instructional design is a complex system since it involves a variety of instructional components and component interactivities which require instructional designers to carefully considered:

- The contextualization and localization of instruction to the pre-existing instructional context (i.e., learning needs, learner persona, available time, resources, and management supports);
- The interaction and constructive alignment of the essential instructional components (i.e., learning objectives, learning modes, instructional methods, and assessments);
- The alignment of design, development, and implementation of instruction products with the evaluation tools for quality check.

When proceeding with an instructional design project, instructional designers first consider the instructional context that sets design constraints for developing instructional solutions. **Instructional context** refers to the learning environment bound by the **target/potential users, available resources, instructional problems**, and **instructional context.** It includes:

- **Instructional problems and learning needs:** Instructional problems and learning needs indicate what is required to be learned for what purpose;
- **Learner persona:** Learner persona refers to the characteristics of target learners or potential learners, including but not limited to learners' physical ability, prior knowledge level, motivation, and interest, learning strategies, social and cultural background, and educational background;
- **Learning environment:** Learning environment refers to the general environment where the learning happens, including the physical settings (i.e., available technology, classroom setting, etc.), and learning context (i.e., psychological environment covering the cognitive environment and affective environment).

These elements interact with each other which forms a rich instructional context. For example, the cultural background of each student forms the cultural environment of the learning group. Instructional designers collect the information of each category but also consider instructional context as a holistic context to inform instructional design.

The analysis of instructional contexts identifies the elements that constrain the instructional design but also act as facilitators to narrow down the range of alternative instructional solutions. **Instructional solutions** state the selected instructional design theories and the design of essential components of instruction. Just as indicated by the learning theories and instructional design theories, important instructional components (i.e., learning goals, learning content, instructional methods, learning tasks and practices, assessment tools, and learning community) and the component interactivity form a complex instructional system. These components can be grouped into four categories, which together form functional **instructional solution.**

- **Learning objectives** refer to the statement of the **to-be-learned content** and the **level of achievement** after the completion of instruction.
- **Learning modes:** refer to the learning settings that determine how instruction is delivered and how learners participate in the instruction. It includes **face-to-face learning, electronic learning (eLearning)**, and **blended learning (bLearning).**
- **Learning methods:** refer to the approaches instructional designers choose to design diverse learning tasks, practices, and learning communities. The basic instructional methods include **lecture and demonstration, micro-learning, drill and practice, game-based learning, simulation-based learning, inquiry-based learning, problem/project-based learning**, and **collaborative learning.**
- **Assessments:** refer to assessment tools instructional designers used to assess learners' learning progress and learning outcomes. The typical types of assessments are **formative assessments** providing constructive feedback for learners to monitor learning and **summative assessment** providing feedback on learners' learning achievement.

The analysis of the instructional context and the development of instructional solutions are two interweaving processes. In this process, information on instructional context informs the decision making, meanwhile the design process might require more context information to make decisions. For example, learners' available times and the available classroom setting might decide if the learning could be conducted in face-to-face learning mode.

In addition, instructional components (i.e., learning objectives, learning modes, instructional methods, and assessment tools) should reach **constructive alignments** to work together as a functional instructional solution. Constructive alignment is a design approach to ensure the instructional and learning activities elicited by the instructional methods can support learners to achieve the learning objectives (Biggs & Tang, 2011). The learning process and learning outcomes are assessed by the assessments which are aligned with the learning objectives. In addition, based on constructive alignment, instructional designers provide guidelines for the instructor (or teachers) to develop an open evaluation space to identify learners' progress and unexpected learning during the instruction.

Based on the instructional solution, the instructional designer develops an **instructional design blueprint**, which provides storylines of the instruction and detailed descriptions of every learning object for developers to develop the learning objects. **Learning objects** refer to any learning content material, learning activity affordance, and assessment that serve specific learning objectives. Instructional designers create and assemble the learning objects into meaningful learning modules and finally roll them out as complete **instructional products.**

Instructional development (ID) models and principles

Instructional Development (ID) Models and Principles

The instructional development (ID) model or **instructional systems development (ISD)** concerns what process an instructional designer should follow to proceed with an instructional design project, which corresponds to the lifecycle of an instructional design project. ID models integrate design thinking with instructional science and provide a systematic structure to manage complex instructional design systems as mentioned before.

The same as the interactive usage of systematic design paradigm and situational design paradigm in applying instructional design theories, Instructional designers follow the systematic procedures of the selected ID model and adjust situationally based on the **instructional development principles.** The selection and adjustment of the ID model depend **on clients' requirements of the instruction, available resources, time, and management support**. There are different ID models an instructional designer could select as a guideline. Instructional designers utilize these models heuristically regarding instructional problems and instructional context.

Instructional development (ID) model

ADDIE model

ADDIE is an ID model standing for the five main steps of instructional design: Analysis, Design, Development, Implementation, and Evaluation. It provides comprehensive guidelines for each phase and indicates the main working outcomes respectively.

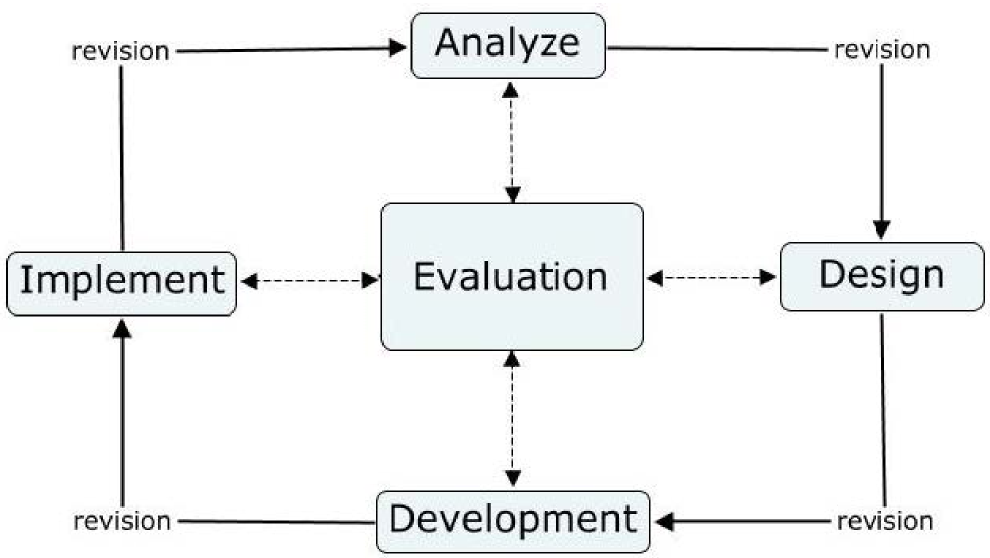


Figure 5 ADDIE model

- **Analysis phase:** Instructional designers analyze the instructional context including learning needs and instructional problems, learning content, learner persona, design constraints (i.e., time, resources, and technology constraints for instruction), and pre-existing learning environment. Instructional designers actively communicate with clients and utilize questionnaires, surveys, interviews, and meetings to collect the necessary information. **Analysis reports** are generated to inform instructional design decision-making.
- **Design phase:** Instructional designers set up learning objectives, select instructional methods and learning modes, and design learning materials, activities, and assessments based on instructional design theories. Instructional designers utilize storyboards to visualize and prototype the instruction and communicate with clients to reach an agreement on the instructional solution. **An instructional design blueprint** is generated to inform the instruction development.
- **Development phase:** Instructional designers choose the suitable authoring software to develop and assemble the content assets that were created in the design phase. Learning objects are developed and translated into the technological requirement of the learning management system. Instructional designers develop instructional products that afford **User experience (UX)** and **user interface (UI)** with different levels of interactivity.
- **Implementation phase:** Instructional designers upload and set up the instruction in the learning management system, train the instructor, as well as evaluate, analyze, and enhance instructional products. The learning objects are revised or redesigned if necessary and **the instructional and learning manuals for the instructors and learners** are provided.
- **Evaluation phase:** Instructional designers use formative and summative evaluation to test the instructional product is accomplished or not, to ascertain whether problems relevant to the instruction are solved, and to evaluate whether the desired objectives are met. **Key Performance Indicators (KPIs)** are set, and **evaluation tools** are developed to evaluate the quality of the outcomes of the analysis, design, development, and implementation phases.

For a detailed description of each step see the **ADDIE model description.** Since ADDIE provides a systematic guideline for each phase and the general hierarchical relationship of each phase, it is easy to use to structure an instructional design project. It also emphasizes the flexibility of moving from one phase to the next phase or getting back to the previous phase for revision (see Figure 6). Instructional designers could use a linear procedure or an iterative procedure accordingly to respond to design needs and requirements.

However, each step in ADDIE models is dependent on the other and the modification of one phase will cause a series of changes in the following phases. Therefore, using the iterative process of ADDIE could be very time- and resource-consuming. In practice, it is more likely to use the linear procedure of ADDIE. The linear usage of the ADDIE model could limit the opportunities and constrain the space for creating, communicating, and evaluating the design alternatives.

Many other ID models are variations of the ADDIE model, but they prioritize certain aspects of instruction which lead to the emphasis on specific phases of instructional design. For example, the Backward design model emphasizes alignment of the instructional activities and assessment with the preset learning objectives, which focuses on the analysis and design phases. ASSURE model focuses on the effectiveness of instructional practices with functional materials, emphasizing the design, development, implementation, and evaluation phases. Dick and Carey's instructional model highlight the quality of the lesson plan generated from the analysis and design phases (For detailed information see https://educationaltechnology.net/dick-and-carey-instructional-model/). Other ID models appear to emphasize situational design paradigms with a focus on flexibility and agility and consensus with other stakeholders.

Successive approximation Model (SAM) model

SAM focuses on the recursive instructional design process which consists of three phases: **preparation**, **iterative design**, and **iterative development**. It is also one of the variations of the ADDIE model. However, instead of emphasizing the systematic design paradigm, SAM seeks to balance the systematic and situational design paradigm with rapid prototypes and active communication with multiple stakeholders (i.e., clients, users, the design team, SMEs, etc.).

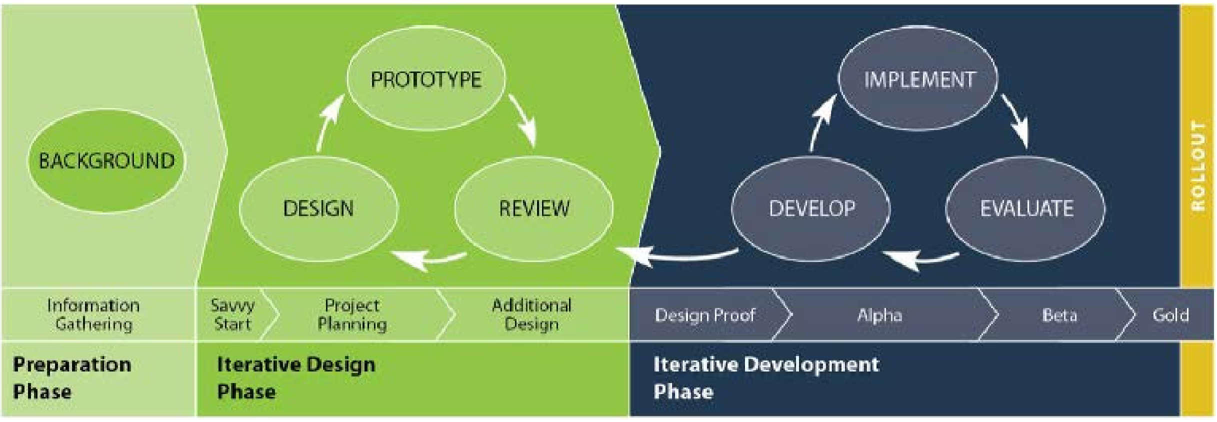


Figure 6 Successive Approximation Model

- **Preparation phase:** Instructional designer collect all needed information and context for the project, from which the content and the scope could be set. This process involves as many stakeholders as possible for brainstorming, sketching, and prototyping. Compared to ADDIE, SAM integrated a more situational paradigm to meet clients' needs and include diverse perspectives.
- **Iterative design phase:** Instructional designers design and prototype the learning objects and the overview of the instruction. Storyboards for UX design and UI design are used as a means of communication among team members and clients. By making conceptual ideas visible, the prototypes can be evaluated, developed, and modified by the design team iteratively.
- **Iterative development phase:** Instructional designers develop, implement, and evaluate the instructional products. The iterative process generates the design proof and α version and finally rolls out the gold version. It can run back to the iterative design phase, if necessary.

For detailed information on SAM see **https://www.alleninteractions.com/services/custom-learning/sam/elearning-development**. The iterative design process creates a space for collaboration and creativity for the project team, which provides opportunities to experiment, test, and revise the designs. Evaluation is integrated into the iterative design and development phases. Feedback is elicited during the iterative process which enables the design team to focus on learners' experiences, engagement, and motivation (Jung et al., 2019). SAM emphasizes agility and collaboration. However, it also means that the adoptions of SAM require a flexible design environment and available active voice from multiple stakeholders during the design and development process. The emphasis on the multiple perspectives might trade with the concerns related to the effectiveness of the learning, which leads to the emphasis on project management in the SAM model for managing the KPIs and the integrated evaluation.

Action mapping

Action mapping focuses on the problem and action analysis, based on which realistic practice activities are developed for learners to solve performance problems. It claims four main design steps:

- **Problem and goal analysis:** Through collaborations with clients and subject-matter experts (SMEs), instructional designers analyze **performance problems** and set up **measurable performance goals**;
- **Action analysis:** Instructional designers **list out the on-the-job behaviors** that learners need to perform to reach the performance goals. It is essential to collaborate with the SME to **prioritize on-the-job behaviors**. It is equally essential to communicate with the learners to identify the **possible barriers to good performance**;
- **Realistic practice activities design:** Instructional designers design the practice activities with **contextual scenario questions** for learners to make behavioral decisions and **scenarios feedback** to activate learners' thinking. Instructional designers usually prototype one activity first and communicate with SMEs and learners on how it works and the possible challenges. Once the prototype is approved, instructional designers outline all the activities and produce all completed activities with the approval of SMEs;
- **Supportive information design:** IInstructional designers identify the information that people must have for each activity and integrate it into the practice activities.

The whole instructional development process focuses on the co-design of activities with SMEs and learners which brings more autonomy, competence, and relatedness. It has a special focus on the action and practice design that could increase the absorption and retention of knowledge. For the detailed workflow of Action Mapping check the link **https://blog.cathy-moore.com/action-mapping-workflow-at-a-glance/**

Figure 7 Action mapping

Action mapping applies the systematic design paradigm by including the essential phases (i.e., analysis, design, development, implementation, and evaluation). However, different from ADDIE and SAM, action mapping emphasizes the situational design paradigm. The design of instruction is the result of prototyping and active communication and discussion with the SME and learners.

Instructional design principles

According to different instructional problems and instructional contexts, instructional designers prioritize the essential aspects of instruction and select the suitable ID model for the instructional design project. Relying on the ID models and instructional design theories, instructional designers follow the systematic procedures meanwhile creatively adjust the instructional design process to develop instructional products according to the following instructional design principles:

- **Problem- and context-centered design:** Instructional problems, design constraints and opportunities situated in a specific context are central to an instructional-design project. Focusing on the instructional problems and the contexts allows instructional designers to make decisions based on the key issues and information rather than the surface elements from clients requirements, such as requirement of using technology in the training (Zhu et al., 2020). All the resulting instructional products (i.e., instructional materials, learning activities, handouts, instructional guidelines) address the instructional problems, empowering users to reach learning objectives and satisfying their learning needs;
- **User-centered design:** Instructional designers involve multiple stakeholders (e.g., clients, potential users, etc.) to communicate the users' needs and how the needs can be addressed. Instructional design process focuses on human-centered learning experience design that involves empathetic understanding of the learners, the sociocultural and technical context in which the learning is embedded, and the individual and socially mediated meaning making process as driven by the learners (Chang & Kuwata, 2020).

- **Functional diversity** of the instructional design team provides multiple perspectives on the problems, contexts, and possible solutions, which contribute to solving the instructional problems. The resulting instructional products should be user-centered that are easily accessed and used by all target/potential learners;
- **Design alignment and creative design:** Instructional design process should align with the chosen ID model. Instructional designers engage in the systematic design process to comprehensively consider all important aspects of a functional instruction. Instructional designers also utilize creative design thinking that adjusts instructional design process situationally based on the specific contexts and instructional problems. The instruction should also align with the pursuing goals of the chosen learning theories and instructional design theories. All components of the resulting instructional products serve the learning objectives which work together as a coherent wholeness;
- **Design principles:** Instructional designers seek to develop instruction with instructional functions (i.e. instruction assist learner to achieve learning objectives), user-friendly materials (i.e. every learners can access and use the instructional and learning materials easily), and aesthetically-pleasing design. Instructional designers logically synthesize relevant research on learning and instructional science to develop courses, training and programme. The design and development of instructional products should take into account of their inclusiveness and utility;
- **Design communication:** Instructional designers engage in active communication within the project team and other stakeholders. Through active communication and collaboration, instructional designers articulate design decisions and build up the instructional products from general ideas, portrayed graphs, and develop prototypes of learning objects and instructional material. The design and development of instructional products should provide rich interactions between learners and learning materials.

Instructional designers follow these ID principles to adjust the instructional design process which results in instructional products that meet the requirements of these ID principles. This process relies on the iterative analysis of instructional problems and contexts that will be leveraged to inform the development of instructional solutions, instructional design blueprints, learning objects, and the final training, course, or program. In this iterative design process, active communication with multiple stakeholders (i.e., clients, learners, subject-matter experts, technicians, etc.) is the key for instructional design decision-making. Facing the diverse instructional design and management tasks, **project management** (i.e., scope management, time management, communication management, resources management) plays important roles in assisting instructional designers to develop instructional-functioning, user-friendly and aesthetically-pleasing instruction (For details see CU 7 Project management).

In addition, instructional designers take the **data security needs** into account once instructional designers receive initiation requests and address the data security needs along the analysis, design, develop, implement, and evaluate phases of the instructional design process. It aims to protect the data obtained from stakeholders, the resulting instructional design products, and data that will be generated when potential learners use the resulting instruction (For details see CU3 Design consideration).

Identities of an instructio designer

Identities of an instructional designer

Instructional designers understand the systematicity, dynamism, and interactivity of the instructional design system and situate themselves in the system to solve the instructional problem. In the rich instructional contexts and the complex instructional design system, an instructional designer develops multiple identities and roles in the real-world instructional design projects.

- **Profession engaging in continuous development:** Instructional design is a continuous developing field along with the development of learning and instructional science, design, and technology. Instructional designers take functional responsibilities of applying learning and instructional design theories, providing faculty technological support, managing projects, collaborating and communicating and ensuring educational quality and innovation with evidence-based activities. These responsibilities require instructional designers to engage in continuous development of expertise in the field of learning and instruction, design, technology, project management and communication. Instructional designers also reflectively engage in instructional design and provide valuable design products and outcomes that could facilitate the development of the instructional design field.
- **Designer with interdisciplinary knowledge:** Instructional designers understand the complexity of the learning environment and the instructional design systems. Instructional designers rely on the conceptual, procedural, and conditional knowledge in related disciplines to identify and analyze the nature of instructional problems, to synthesize the issues in a project, to leverage the information for the design tasks, to adopt the suitable technology for instruction, and to understand the intertwined instructional design tasks. The interdisciplinary knowledge also facilitates the communication within the instructional design team, where experts from different fields can share or easily develop shared understanding of the instructional solution within contexts.
- **Problem-solver taking multiple perspectives:** Instructional designers are reflective problem solvers who understand the iterative instructional design process. During the instructional design process, instructional designers can take multiple perspectives to comprehensively analyze the problem and context as well as design and develop problem-, context-, and user-center instruction. Instructional designers also take the holistic and diverse perspectives to understand and examine the interaction between instructional components in a complex learning environment. With the diverse perspectives, instructional designers are more capable of using different ID models heuristically to address the key issues and problems.

- **Team player with intercultural and collective competence:** When designing instruction, instructional designers address cultural variables in society, institution, instruction, learning content, and learning groups to create inclusive and culture-sensitive instructions. Instructional designers recognize and understand the impact of cultural variabilities on human communication and learning. Instructional designers also consider the intersection between culture, technology, political and historical influences that shape each learning context, where the user interface design should consider how different cultures respond to the graphical interface, images, symbols, colors and sound. Therefore, instructional designers rely on the intercultural and interdisciplinary collaborations for to facilitate both instructional design process and the development of cultural-sensitive instruction. Through the active collaboration, Instructional designers actively develop in and contribute to the local and global instructional design communities.

Conclusion

Conclusion

Instructional design is a systematic and creative design process. Instructional designers rely on ID models to structure the design tasks and creatively manage and coordinate the instructional design tasks. In this process, instructional designers utilize interdisciplinary knowledge to develop problem-centric, context-bounding, learner-centered and culture-sensitive instructions. Technology is widely used in learning activities to support learning and instructional design processes. In real-world instructional design practices, instructional designers continue to develop multiple identities and interdisciplinary expertise.

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Co-funded by the European Union

The European Commission support for the production of this publication does not constitute endorsement of the contents which reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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Project number 2021-1-PT01-KA220-VET-000034676