Transfer of Learning and Teaching: A Review of Transfer Theories and Effective Instructional Practices

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Abstract

One of the primary goals of education is to ensure that learners can apply their acquired knowledge in various ways and under different circumstances. However, this expected "transfer" does not always occur and, therefore, the acquired knowledge cannot be flexibly employed in different contexts. One way to minimize this problem is to understand how transfer occurs and what learning conditions can improve this process. This review paper provides major theoretical perspectives and pedagogical practices to explore the most effective ways to optimize knowledge acquisition and transfer. The results of the comparison of the selected theories indicated that transfer was a multi-dimensional process that could occur at any stage of learning and could be enhanced through coaching, scaffolding, interacting, assessing and reflecting in situated learning environments.

Keywords: transfer of learning and teaching, situated learning

Many researchers have defined transfer as the productive application of prior learning and experiences in novel contexts (Gass & Selinker, 1983; Gick & Holyoak, 1987; Roediger, 2007). While the definition of a "novel context" may initially appear ambiguous, most transfer studies consider a novel context as a situation that is potentially different from the original situation in which learning has already taken place (McDaniel, 2007). Thus, applying knowledge to a different domain, aligning it with a new goal and being assessed differently, can all be considered as novel contexts (Barnett & Ceci, 2002; Pan & Richard, 2018).

A large body of research indicates that students often find transferring knowledge to situations other than the one in which it was learned highly challenging (Gilbert et al., 2011). Therefore, many educators and researchers have attempted to identify the factors that influence later acquisition of knowledge by examining the cognitive and metacognitive processes that occur during the learning process. The result has been a vast amount of literature with various perspectives towards learning and instructional practices along with large variability among findings (Blume, Ford, Baldwin, & Huang, 2010). Therefore, the goal of this article is to review some of these theories to identify the consistent factors that facilitate knowledge transfer and provide examples of the instructional strategies that can provide optimal opportunities for learners to apply their acquired knowledge and expertise.

Since discussing all theories from transfer literature is beyond the scope of this review, only a few traditional and contemporary theoretical perspectives will be provided and discussed. These theories begin with the traditional cognitive theories of transfer and end with more contemporary learning transfer theories. However, the selected instructional practices will predominantly be based on social constructivist approaches to learning such as situated learning theory. The reason for this choice is the extensive employment of contextual and inquiry learning methods in science and technology research and the presence of empirical evidence for successful application of these methods (Aparicio-Ting, Slater, & Kurz, 2019; Potvin, Hasni, & Sye, 2017). At the end, some of the advantages and disadvantages of the stated theories will be discussed and several pedagogical suggestions will be provided.

Theoretical Models of Transfer

Theory of Identical Elements

Learning transfer has become a significant research topic in educational psychology since Thorndike and Woodworth developed the theory of *identical elements* in 1901 (Schunk, 2004; Singley & Anderson, 1989). According to this theory, learning can be transferred from one activity to another (e.g., training to performance) if the two activities are highly similar and share many common elements. The level of transfer is also determined by the level of similarity between the original context of the training and the target context of the performance. Thorndike conducted a study on 8,564 high school students and noticed that the art and science courses taken by the students had very little effect on their problem-solving skills. For example, subjects such as math, physics, chemistry, Latin and French had very little effect on strategic thinking and problem-solving skills. While the challenging practices of learning sciences had helped students develop general learning skills and intellectual abilities, it had not helped them develop efficient problem-solving abilities required to tackle real life problems. He therefore emphasized the significance of the relationship between the content taught in school and the demands of real-life skills. Identical elements theory challenged the traditional view of teacher-centered pedagogy and became one of the pioneers of active learning theories. This view of learning was followed by Dewey's pragmatic view of learning and his idea of inquiry learning classrooms. According to this view, classrooms need to represent real life situations and provide opportunities for students to flexibly participate in distinct learning activities and in distinct social contexts (Dewey, 1938; Gutek, 2014; Williams, 2017).

Theory of Low and High Road Transfer

In 1989, Perkins and Salomon developed the integrative theory of "low and high road transfer". According to this theory, there are two different, but connected, underlying mechanisms for transfer, namely, low road and high road. Low road transfer usually occurs when the target and original activities share a countless number of features. For example, a person who is driving a small truck for the first time usually finds the experience very similar to the experience of driving a sedan car. Driving the truck is the same habitual experience although it seems like a different task (Perkins & Salomon, 1989; Perkins & Salomon, 1992). These reflexive behaviours or automatic responses in similar activities are the result of countless hours of practice. However, high road transfer occurs as a result of mindful abstraction of general principles among different events in different contexts and a deliberate search for connections among their structures. For example, a person who takes a C++ programming course and is assigned a game development project at the end of the semester needs to ensure that he or she knows the programming language well and then deliberately search for the connections between what has been learned and what needs to be designed in a novel context. Similarly, learning Newton's Laws in a Physics course and applying them to building an aircraft model needs flexible adaptations of underlying principles to a completely new environment. High road transfer demands time for exploration, discovery, flexible adaptation of skills, and asking questions such as what the problems are, what principles need to be applied and how the final outcomes need to be assessed. In practice the low and high road theory has offered two ways for learners to increase their chance of applying their knowledge in different situations flexibly: effective practice and mindful abstraction of knowledge (Perkins & Salomon, 1988, 1989, 1992).

This theory leads to two broad instructional strategies in fostering transfer: "hugging and bridging" (Perkins & Salomon, 1992, p.10). Hugging is an instructional strategy that directly guides and engages the learner in the desired target performance and therefore promotes reflexive transfer. For example, a teacher might give students sample exam questions rather than just explaining how some particular strategies may help them succeed in the exam. Similarly, a university job counselor might encourage students to engage in mock interviews rather than just providing them with some general rules of effective job interviews. This way the learning experience hugs the target performance and optimizes the likelihood of automatic performance in similar situations (low road transfer). On the other hand, bridging employs the high road to transfer. This instructional strategy encourages intentional abstraction of the general rules by searching for possible connections among various experiences or examples and applying them to unknown cases. For example, an instructor who prompts students to adopt an exam strategy based on their previous experiences creates an opportunity for students to analyze and reflect on their strengths and weaknesses and create a general strategic plan for their future exams. To maximize high road transfer, instructional designers need to create generic skills that can be used in various situations and not uniquely applicable to their original context (Winn, 1993).

Theory of Analogy and Abstraction

Abstraction is one of the most fundamental principles of many cognitive theories of transfer. As Skemp (1986) defines it, abstraction is "an activity by which we become aware of similarities among our experiences" (p. 21). By identifying the underlying principles of actions, thoughts, perceptions, and operations we can facilitate the transfer of knowledge to contexts that are fundamentally dissimilar from those that are initially encountered (Gick & Holyoack, 1980; Hayes & Simon, 1977).

There is ample evidence that understanding of the world is based on abstraction rather than superficial comprehension of various systems and their relationships. This is particularly true in understanding and discovery of underlying scientific principles. For example, in a biology course the goal is to understand the genetic laws behind multiple generations of pea plants and not the particular properties of the plants in isolation. Similarly, in physics the goal is to find out the fundamental principles of conservation of energy and not watch what happens to a particular spring when it is weighted down (Chi, Feltovich, & Glaser, 1981). In fact, the progress of science and mathematics is mostly due to the deep conceptual principles shared by the phenomena that may look dissimilar on the surface but which are defined in terms of the same categories or models (Goldstone &Sakamoto, 2003) such as the underlying principles of Golden Ratio in nature or the Fibonacci pattern in reproduction.

One effective mechanism for abstraction is analogy (Gentner & Hoyos, 2017; Hajian, 2018). Although analogical transfer may seem intuitive and natural, it is based on complex mechanisms that need to be employed for extraction of commonalities among various cases and discarding the unrelated information (Gentner, 1983; Gick & Holyoak, 1983; Hummel & Holyoak, 2003). For example, when a person knows how to solve a linear equation with unknown variables added together, it is highly possible that the person also knows how to solve the linear equations with different operations (e.g., subtraction, multiplication, and division) using analogical comparison. Analogy and reasoning can lead to efficient problem-solving strategies which are based on four components of retrieval of information, mapping structures, transferring solutions, and generalization (Gentner, 1997; McFate & Forbus, 2016). Among all these components, it seems that retrieval and access to the source analogue is the most challenging process. And therefore, it can be performed successfully if explicit scaffolding such as hints and cues are provided for finding a suitable source for analogy (Gentner et al., 1994; Holyoak & Koh, 1987; Schmid, Wirth, & Polkehn, 2003). Evidence shows that many university students often fail to employ structurally similar analogies spontaneously (Gick & Holyock, 1980; Hayes & Simon, 1977) although using this strategy can greatly facilitate the process of creation of new schemas (Gentner & Hoyos, 2017). Given the critical role of structural similarity and mapping in schema formation and successful transfer (Holyoak & Koh, 1987; Reed, 1989; Salomon & Perkins, 1989), it is important to include analogy as a supportive mechanism of instruction and knowledge assimilation (Chi, Slotta, & De Leeuw, 1994). Additionally, analogies can be employed as exploratory and creative tools for solving complex relational problems (Duit, 1991; Glynn, Britton, Semrud-Clikeman, & Muth, 1989). For example, a novice looking at a chessboard in the middle of the game becomes overwhelmed by the huge amount of information required to be processed whereas a chess expert can very quickly recognize the structural similarities among various positions and relations and work with manageable meaningful structural pieces (Chase & Simon, 1973).

Given the power of analogical comparison in knowledge transfer, along with many other robust cognitive mechanisms of transfer, such as self-explanation (Chi et al., 1994; Rittle-Johnson, 2006; VanLehn & Jones, 1992) and test-enhancement strategy (Pan & Richard, 2018; Roediger & Butler, 2011), how can educators incorporate these mechanisms in instruction to promote expert learning? A number of studies addressed this question in the 1980s and indicated that the possible solution was learning in similar contextual environments. It appeared that from practical point of view "contextual similarity" between various situations plays a higher significant role in determining whether transfer can actually occur (Day & Goldstone, 2011).This view criticized the cognitive learning models employed in schools as decontextualized and individualized pedagogical models that led to independent possession of knowledge by the learner (Wilson & Myers, 2000). The idea that concepts are abstract, self-sufficient, and separate from the context does not support the idea that learning is an active and engaging process (Bonwell & Eison, 1991; Brown et al., 1996). Furthermore, acquiring abstract knowledge does not guarantee transferrable knowledge – this is similar to a situation when a person has quality tools but is unable to use them. The gap created between knowing and doing prevents learners from using their knowledge within an appropriate context (Bransford et al., 2000; Brown, Collins, & Duguid, 1989).

Situated Learning Theory

Although some of the major transfer theories developed simultaneously, it was the theory of "situated learning" (Lave, 1988) that integrated most of the separate branches of investigation into a more complete theory of learning and transfer. In this view, learning and cognition are situated and developed through purposeful authentic activities in social contexts. Therefore, learning and transfer occur when learners are given an opportunity to "observe and practice *in situ*" (Brown et al., 1989, p.34).

This theory is founded on the principle that knowledge is constructed if the learner becomes an active participant of a highly connected community in which knowledge and culture are integrated. Learning should also be an unintentional process rather than a deliberate one – a process that can take place through "legitimate peripheral participation" (Lave & Wenger, 1991).

What Lave (1988) observed in her work with apprentice tailors is a good example of how learning can occur as a social phenomenon and how novices become experts through legitimate peripheral participation (LPP). She noticed that newcomers to the community of professional tailors began their jobs by doing lots of trivial tasks such as running errands, preparing the materials for the tailors and cleaning the workspace. Then, they helped the masters by finishing the details of the clothes and gradually helped them more and more with advanced jobs until they became experts themselves. Lave argues that the trivial looking jobs performed at the initial stage of learning are not trivial at all as they provide an opportunity for novices to familiarize themselves with the fundamental knowledge required for that community. The small responsibilities progressively change to more advanced activities such as cutting, sewing, and designing (Lave & Wenger, 1991). Therefore, it is mostly through participation within a community of practice that learning and transfer can gradually occur. This is similar to the foreign language learning process which is only possible through application of words and grammar "within" society and not just memorization of isolated words from the dictionary. For example, in the study conducted by Preston et al (2015), it was shown how context-aware systems could help learners keep track of their progress during an activity and how this strategy allows them to take language learning to a level beyond the traditional environment of the classroom.

Lave and Wenger define community of practice as members of the same group, with shared interests, goals, and passions participating in a sociocultural practice on the regular basis. Cognition is developed in this type of practice (Chaiklin and Lave, 1996; Lave, 1988) and novices can become experts through moving from peripheral participation to the central role of the community with more expertise (Lave, 1988; Chaiklin & Lave, 1996). The idea of cognition in practice supports the significance of the instructional cognitive apprenticeship model in learning and transfer of complex skills (Brown et al., 1989). It is important to know that the concept of "participation" does not only refer to informal or unplanned activities. Participation can also be an arranged activity in formal lessons, laboratory experiments, scientific conversations and workshops within the same community (Wenger, 1999).

The role of cognitive apprenticeship in learning has been demonstrated for various skills such as mathematics, reading and writing (Brown et al., 1989), genetics (Charney et al., 2007), chemistry education (Stwart & Lagowski, 2003), learning clinical skills (Wooley & Jarvis, 2007) and web-based problem solving (Kuo, Hwang, Chen, & Chen, 2012). All these studies provide evidence that learners need to immerse themselves in authentic learning environments and gain expertise through participation in the community of practice (Brown et al. 1989; Greeno & Moore, 1993; Herrington and Oliver, 2000; Lave, 1988). For example, in the study conducted by Preston et al (2015), it was shown how context-aware systems could help learners keep track of their progress during an activity and how this strategy allows them to take language learning to a level beyond the traditional environment of the classroom.

Instructional Practices

One of the most efficient ways to assist learners to adapt to the demands of novel situations is to provide them with appropriate knowledge and skills that are necessary to confront and solve complex real-life problems (Brown & Duguid, 1993). One effective practical way to implement this idea is to design a pedagogical environment that can provide an authentic environment and authentic activities so novices can have access to expert performance, scaffolding at critical times, sufficient support for collaborative construction of knowledge, and monitoring within the learning environment (Herrington & Oliver, 1995, 2000).

Although it is difficult to implement a program that integrates all of the above factors, it has been shown that pedagogical models such as problem-based learning (PBL), community of practice (CoP), cognitive apprentice (CA) and game based learning (GBL) can integrate many components of the situated learning theories such as collaboration, coaching, practice, problem solving and reflection. There is ample evidence that these models can be implemented successfully in educational practices and make significant changes in student learning and transfer abilities.

Problem Based Learning (PBL)

PBL is founded on four principles of "constructive, self-directed, collaborative and contextual learning" (Dolmans, De Grave, Wolfhagen, & Van Der Vleuten, 2005, p.732). In PBL both learning and teaching are problem driven. The ill-structure problems used in PBL allow learners to create connections between theory and practice to develop the required ability to handle complex challenges of real-life situations (Hung, 2013; Savery, 2015).

Reflection is one of the most critical components of PBL as learners constantly need to monitor their conceptual and procedural understanding for effective learning and adaptive problem-solving strategies. This monitoring process allows refinement of knowledge and supports learners in discovering the underlying structural relations between concepts and categories (Hung, Jonassen, & Liu, 2008; Jonassen & Hung, 2012). Self-directed learning (SDL) is another crucial component of PBL that is fundamental to the development of far transfer ability. SDL requires reasoning skills and analytical approach towards the issues that arise in the process of learning and application. These skills allow the learner to develop cognitive flexibility and decision-making ability required for tackling unanticipated novel problems (Nerali, Telang, Telang, & Chakravarthy, 2016; Stolper et al., 2011). PBL has successfully been implemented in many science courses such as physics (Celik, Onder, & Silay, 2011), mathematics (Ronis, 2007) and medical education (Barrows, 2000).

Communities of Practice (CoP)

Communities of practice are shaped by individuals who have highly similar concerns or interests and are willing to encounter challenges related to their shared interests or concerns through collaboration and interaction together. What makes a community of practice productive and functional is an effective leadership. A leader (coach or tutor) facilitates collaboration and fosters participation during the process of learning (Schwarz, 2002). For example, in the community of practice of the classroom, the teacher takes a leadership position by facilitating the actions and decisions of a group of students (Shields, 2003; Wenger, 2000). This collaboration can also occur in a virtual context such as a multiuser online discussion board or a virtual lab. Although the physical presence is missing in these environments, communities of practice can still be formed in a highly dynamic manner. A good example of promoting CoP in an online classroom is assigning group projects that can be performed in collaborative documents such as Google Docs. Using online sharing document software, learners can discuss their ideas in real-time, evaluate their work together, edit the document as a team and generate new goals and ideas for their future collaborative projects. In fact, virtual environments may contain a variety of unique features that cannot be found in physical CoP environments.

Cognitive Apprenticeship (CA)

Cognitive apprenticeship is strongly based on “modeling, coaching, and fading” (Brown et al., 1989, p.39). An expert coach (e.g., a professor) begins to promote learning through making his or her tacit knowledge explicit and model the required strategies in an authentic activity for students (Brown et al., 1989). Students use the provided knowledge, manipulate it and discover their own way of managing knowledge. For example, graduate students learn how to do proper research by working on an authentic research project with their supervisors as opposed to learning the principles of research from the books and practicing the learned principles at the library. The supervisor monitors the resources used by the students, guides them through the process of research and provides them with the opportunities they need to tackle authentic complex research problems. The professor also provides coaching and scaffolding along the way if required. In fact, monitoring and providing feedback are highly pivotal to this process. Unlike the traditional apprenticeship system that is only focused on concrete physical skills, cognitive apprenticeship emphasizes on all the cognitive and metacognitive processes that are involved to achieve mastery of the field. As Brown et al. (1989) argue this model is founded on “learning-through-guided-experience on cognitive and metacognitive skills and processes” (p. 457).

Many studies have provided evidence on the role of this model in improving student learning transfer in different areas. For example, in the study conducted by Wedelin and Adawi (2014), in a mathematical modelling course, those who worked with supervision in a cognitive apprenticeship environment (e.g., in pairs of an expert and a novice) demonstrated significant changes in their mathematical thinking and modeling in real work projects. The students also considered the course as one of the most productive and creative courses taken in their entire program.

Similarly, in another experiment conducted by Chiu, Chou, and Liu (2002), the results indicated that grade 10 students who learned chemical equilibrium in a cognitive apprenticeship context gained better understanding of this phenomenon compared to the control group. They also managed to solve more challenging problems than the control group.

Teaching in a cognitive apprenticeship environment is highly successful in preparing students for confronting complex problems in the workplace or any authentic context as this instructional practice is based on modeling, coaching, scaffolding, discovery, articulation, and reflection (Schoenfeld, 1985). Therefore, the implementation of this educational model is highly recommended in promoting learning transfer and problem solving in science and engineering. One of the challenges of implementing this model is the requirement of a small teacher to learner ratio, which may not be possible in large classes or groups.

Game Based Learning (GBL) and Simulations

Educational games and simulations can also provide pedagogical contexts in which learning can effectively take place under particular pedagogical conditions (Clark, Tanner-Smith, & Killingsworth, 2016). These interactive environments allow learners to check their understanding of the real-world phenomena through observing, modelling, comparing, testing, and reasoning. For example, simulations can provide immersive model-based environments that allow learners to simplify or challenge the concepts or the principles they are learning (e.g., the principle of conservation energy or principles of chemical equilibrium) and expose themselves to various dimensions of the learned principles (e.g., the multiple ways a formula or a concept can be applied). Additionally, the embedded features of the simulation allow repetitive practice along with real-time feedback on the user's learning progress in the environment (Dede, 2012). For instance, the immersive game of Spore ("Spore ™", 2018) provides an opportunity for learners to repeatedly design creatures that can transform through numerous stages of evolution and develop into new varieties. Despite some scientific imprecision, players can directly observe their creatures and their effects on the ecosystem. This interaction with the system allows players to constantly apply what they have learned about evolution and continuously modify their designs to ensure what has been learned is valid and applicable.

SimCity ™ ("Electronic Arts", 2018) is another simulation that has been used for engaging learners to build cities that can continuously evolve. Interestingly, this simulation shows the user how the choices they make in the game can have dramatic consequences on the life of people, businesses, and natural resources. Incorporating such simulations in the curriculum provides a great opportunity for students to assess the functionality of their constructed cities in comparison to the similar designs in the real world. It also allows them to analyze the effects of their construction on the health of the ecosystem, environment, economy, the future of agriculture, and many other challenges of today's modern world. In fact, in the recent study conducted in an urban geography course, the university students who used SimCity to construct their own cities had a greater opportunity to apply the theories they had learned to support their urban structures. They also needed to use urban geography principles to critically evaluate the rationale behind their constructed system in the SimCity compared to a counterpart design in the real-world. This activity greatly advanced students' creativity, originality, and imagination and resulted in multiple interesting cities with unique designs. The findings demonstrated that an immersive educational environment can be a highly effective tool for promoting learning transfer in geography and civil engineering education (Kim & Shin, 2015).

Immersive technologies can greatly help educators implement pedagogical approaches that are aligned with the situated-constructive learning theories. Well-designed simulations and games provide immersive environments with appropriate tools, content, feedback, and scaffolds that are necessary for meaningful cognitive and metacognitive learning and transfer. In such environments learners can explore, observe, question, and learn through peer coaching and legitimate peripheral participation (Dunleavy, Dede, & Mitchell, 2009). That is probably why one of the fundamental goals of educational researchers is to develop the pedagogical games that can create the same level of motivation, engagement and passion produced by some popular commercial video games (Lu et al., 2016; Young et al., 2012).

Discussion

Defining transfer and finding its underlying mechanisms is a challenging task. Researchers are still trying to understand the challenges that learners encounter when they try to extend their knowledge from one context to the other. Most traditional assumptions about transfer are primarily founded on the idea that educating people through instruction, guidance and practice in a particular context can help them gain mastery of a particular task of a domain and this mastery is all that is needed to utilize knowledge in practice. While the modern constructivist theories of learning do not underestimate the role of instruction and practice, they view learning as a whole, integrative process in which learners are actively engaged in the process of their own learning while they receive appropriate instruction, guidance, feedback and opportunities through social interaction and involvement in authentic experiences. Therefore, learning is not merely defined in terms of the cognitive processes that individuals are engaged in. It is also about how individuals evolve in this process and change (Lave & Wenger, 1989; Singley & Anderson, 1989).

This paper reviewed some of the prominent learning and transfer theories such as the theory of identical elements, low and high road transfer, analogy as well as the situated learning theory. While each theory employs effective cognitive and metacognitive strategies such as comparison, assessment, reflection, and generalization, which can significantly improve learning and transfer, each approach has also some limitations that need to be considered when these approaches are implemented in practice.

For example, while the ultimate goal of the identical theory of transfer has been to improve students' application of knowledge through providing similar tasks in similar contexts (with shared elements and features), this theory was criticized years ago by Hendrickson and Schroeder (1941) when they empirically indicated that the ability of formulization of general principles (e.g., the principle of water refraction) was more effective than the presence of highly similar tasks in transfer of training. It was also noted that other factors such as individual differences such as the habit of verifying a judgment or the ability to generalize a principle for oneself highly influenced the amount of skills and knowledge transferred.

Early research on knowledge transfer was mostly directed by the theories that were focused on the resemblance between "conditions of learning and conditions of transfer" (Bransford et al., 2000, p.51) – a difference that was addressed and questioned by later theories. However, are learning and transfer truly different? In answer to the question, Perkins and Salomon (1992) argued that there is no solid line between learning and transfer. However, transfer becomes interesting when it occurs beyond the original context of learning and is not considered ordinary learning anymore – a phenomenon that they called "the hoped-for transfer" or desired transfer. For example, a student may indicate very good vocabulary skills on the English test (ordinary learning) but not in daily speech (the desired transfer). The student may be quite comfortable with solving the problems on the worksheet (ordinary learning) but not similar questions in an authentic problem-solving context (the desired transfer). The idea of ordinary versus desired transfer can also be explained in terms of "near" and "far" transfer (Kassai, Futo, Demetrovics, & Takacs, 2019; Perkins & Salomon, 1992). Near transfer refers to application of the same knowledge in vastly similar contexts. For example, when students encounter problems similar to what they have previously practiced in their homework or when a mechanic fixes an engine which is similar to the older designs of the same model, the transfer is near. On the contrary, far transfer is about utilizing knowledge in remote and dissimilar contexts. For example, a chess player might apply basic strategic principles of the game such as center control to investment practices or to sports games or an engineer may apply the trigonometric principles to a modern design. It should be noted that the definition of near and far in this context is highly intuitive and, therefore, there is no specific measurement to determine how far or close the events are.

It is important to know that transfer does not always convey a positive concept although by transfer we usually mean learning in one context and improvement in performance in some other context. Negative transfer may also occur when learning in one context negatively influences one's performance in another context (Chen & Daehler, 1989; Cormier & Hagman, 2014; Perkins & Salomon, 1992). For example, when speakers of one language find it easier to learn related foreign languages, the transfer is positive. However, if differences in pronunciation, vocabulary, and grammar create confusion for the learner and hinder their learning process, then the transfer is considered negative. While negative transfer can be a real and problematic issue in learning, it does not seem as significant as positive transfer in education. This is mainly because negative transfer can usually be problematic in the early stages of learning a new domain and learners often correct their misconceptions when they gain experience in their field of study. Therefore, the main focus of transfer research is to know when, where, and how the desired positive transfer occurs.

Similarly, in applying transfer strategies such as analogical encoding, one needs to be aware of the potential challenges that may arise later. Empirical research indicates that analogical encoding – which occurs through comparison among similar examples and cases – can be highly effective in formation of new concepts, producing general rules, and promoting problem solving strategies (Gentner et al., 2003; Gick & Holyoack, 1983; Hajian, 2018). However, comparison may also lead to overgeneralization and incorrect conservation of variables due to the application of the intuitive rule of "same A – same B" (Ronan, 2018; Stavy & Tirosh, 2000). For example, as Ronen (2012) argues, when two rectangles with the same area (but different lengths and widths) are turned into two cylinders, they end up with the same area but different volume. However, many learners conserve both area and volume under this transformation (as cited in Ronen, 2018).

One way to confront this challenge is to stimulate students' awareness to their intuitive incorrect responses and challenge their reasoning by employing appropriate prompts and scaffolding at appropriate stages of learning (Hajian, 2018; Lazonder & Harmsen, 2016; Ronan 2018). For example, it is highly effective to prompt students to explain why and how they have abstracted a general rule and what evidence they can provide to support their justification (Hajian, 2018; Holyoak & Thagard, 1996; Hoyos & Gentner, 2017).

There is no doubt that each reviewed theory has its own complexity and challenges in implementation and practice. These challenges are mainly due to factors such as the level of learner motivation, engagement, attention and prior knowledge. Therefore, novice learners and expert learners may take advantage from the same training in different ways as the association between learning and transfer also depends on the level of knowledge and expertise that learners have previously acquired in the field (Gentner et al., 2003; Hajian, 2018; Kalyuga, Chandler, Tuovinen, & Sweller, 2001).

Transfer is an active, dynamic process and not the final product of some sequential steps in learning or a passive end-product approach. This paper provided some practical educational models such as problem-based learning, communities of practice, cognitive apprenticeship, and game-based learning to indicate that it is possible to efficiently promote learning transfer in a relatively authentic context – *in situ* learning. However, there are still many questions that need to be addressed in future studies. For example, do all skills need to be acquired within a social context to ensure their successful application? How is situated learning implemented in online courses and materials? What kinds of instructional support are required to be provided for learners with different prior knowledge and self-regulatory behaviours? And, how can in-situ learning model be employed in our traditional school system, considering a big volume of material needs to be covered in a relatively short period of time?

In conclusion, learning transfer is a multi-dimensional process that occurs at any stage of learning and can be enhanced through coaching, scaffolding, interacting, assessing and reflecting in authentic contexts. Therefore, if learning transfer fails, the entire learning system needs to be questioned simply because many things might have gone wrong and there are no quick-fix strategies to solve the problem.

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