Chapter 7
Development of Physical Actions

Outline of Lecture 7

In this lecture, Galperin discusses the process of the *development of physical actions*, which are also referred to as *motor skills*. He identifies that a skill can be both a characteristic of an action and an indicator of the excellence of the performance of the action. However, the focus is on the development of physical actions in which the *executive part* remains on the external plane, and the *orienting part* undergoes development by transferring through speech to the mental plane of the learner. Galperin argues that physical actions can be developed by employing two types of orientation: incomplete and complete. In an *incomplete orientation*, which Galperin termed *the first type of orientation*, a learner acts by trial and error, and after numerous trials, some may appear to be successful. The development of a psychical action in the first type of orientation comprises two phases: first, a learner seeks an action that leads to a successful outcome; second, a learner directs his or her efforts to improve this action. Galperin describes this approach to mastering physical actions as unconscious and not understood because the relationships between the action and the external conditions remain unrealised by the learner. In addition, this approach is unproductive and extremely time-consuming. This is an example of spontaneous learning, and the significant part of this learning process happens uncontrollably and remains unrealised by the learners. The result of such a process is that in a group of students, there is always a wide variety in their academic achievements. Moreover, the developed actions are sensitive to any changes in the conditions of the actions: learners do not achieve similar results after several attempts. In traditional education, these variations are explained according to learners' individual abilities. Galperin argues that *learning is a psychological process and, therefore, to* examine learning, one needs to explore its psychological grounds. These grounds comprise *learners' orientation in the learning process.* To develop a physical action, the desired outcome and the sequence of the operations needed to achieve this outcome should be identified. *The complete orientation*, which Galperin terms *the second type of orientation*, might

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offer an approach to developing physical actions. In the learning process after the complete orientation, students utilise the orientation scheme created by the teacher to develop an action; hence, unnecessary trials and mistakes should not occur. Most learners develop the desired action, and there are almost no variations among their achievements. Galperin offers three examples of the approach in case studies that aimed (i) to teach children to write, (ii) to teach them to work on metal-cutting machines, and (iii) to teach them how to use a bow saw. Galperin summarises that when a complete orienting basis of the action is offered, the action is performed correctly by students in the first attempt, and the skills developed during this action are stable and can be transferred to other situations. By using a complete orientation, students develop a positive attitude toward the process of learning by engaging in the learning process, not by trial and error but consciously. Galperin concludes that in developing learners' conscious skills, *the duality between skills and knowledge disappears.* Finally, Galperin describes the process of the *automation of action* through the formation of bigger units of the action and then by merging all units into one continuous flow of the action.

Lecture 7

In this lecture we will discuss the process of the development of physical actions also referred to as motor skills. Since the term *skills* is used in that case, I would like to note that a skill is not an independent phenomenon; it is rather a characteristic of an action. Sometimes a skill is considered an indicator of the excellence of the performance of the action, because it may reflect different degrees of mastery. However, we have to bear in mind that a skill is not always defined this way, because skills may vary in development. In some cases, the achievement of the highest degree of performance of the action —that is, the development of the best possible skill —may actually hinder further development. Therefore, we have to understand that a skill is only one characteristic of an action, although a very important one.

In this lecture we will not talk about skills as such, but about physical actions in which the executive part remains on the external plane and the orienting part undergoes development, which may happen in two ways. For example, with animals, the orienting part remains in the plane of perception and transforms into an ideal action. With humans, the orienting part always transfers through speech to the inner mental plane of a learner.

To perform an action correctly, a system of conditions is required. But this system is not always supplied to the learner and then the learner may act by using an incomplete orientation. To summarise, physical actions can be developed by employing two types of orientation: incomplete and complete. There also exists the third type of orientation, the most advanced, though I will not talk about this type yet.

If a learner has only an incomplete (essentially incomplete) orientation available and cannot improve it himself (sometimes a learner may be able to find the missing elements of the orientation), then, naturally, the learner must act blindly through trial

and error. Inevitably numerous trials happen, very often erroneous and sometimes, by chance, successful. The successful trials are singled out and remembered and gradually the structure of the successful action is developed. This means that with the first type of orientation, the development of a physical action happens through trial and error. So far, this has been the only type of orientation used for the development of physical actions.

The process of developing a physical action with the first orientation type comprises two distinctive phases which are unequal in length. In the first phase the learner seeks an action that leads to a successful outcome. This is the development phase of the action. After the desired action has been found, then the learner directs his efforts to improve this action. This is the second phase, the improvement phase of the physical action.

In the first phase of the action's development with the first type of orientation, numerous trials and errors are inevitable, because a learner has no instructions about how to perform the action and he seeks a way to perform the action. If we are to present this process graphically, we would plot the successful achievements on the vertical axis and the consecutive trials on the horizontal axis, and we would get an ascending curve, i.e. gradually, the productivity of the attempts of the learner increases. If, the other way around, we plot the number of unsuccessful trails that the learner attempts before he finds the desired action on the vertical axis and the number of attempts on the horizontal axis, then, as the number of attempts increases, the number of unsuccessful trials decreases.

This means that the curve of the development of the action, depending on the factors that you plot on the vertical or horizontal axes, may either ascend or descend. However, each of these curves has specific characteristics, which have been described in detail previously. First, this is never a straight ascending or descending curve. This curve is always a zigzag, which shows successful and unsuccessful attempts the learner pursues with the aim to develop an action. Second, on this curve, characteristic periods are often observed during which the zigzag remains, but in general, despite ongoing attempts, it seems to stay at the same level. Then the curve starts to gradually descend until it levels up, which may indicate that the learner has achieved a period of stable skill, although the skill has not yet reached its best characteristics. There are different theories that explain these periods of levelling up, but this is a different matter and we will touch upon it later. What is important is that there is always a characteristic curve that shows the development process of the action. This curve is inevitable, because the learner lacks the essential orienting instructions on how to perform the action correctly.

This curve, which is always present in the first type of orientation, gave rise to an understanding that such a development process of a new action is absolutely unavoidable and even necessary. Researchers, in collaboration with practitioners, attempted to give a theoretical explanation of this process: for a new action (especially when it can be characterised as a skill, that is, performed with a certain measure of automaticity), new neuromuscular reflexes are needed, or new pairings of nervous impulses in the brain and appropriate muscular responses should be developed. This is a very complicated matter. It is important to understand that we cannot voluntarily

develop our nervous processes—they are not the object of our control. Therefore, we have to send random impulses and "catch the moment" when these impulses result in a desired activity. This means that the whole process of numerous attempts and trial and error is inevitable, simply because new neuromuscular reflexes can only be found by chance. Only when these reflexes have been identified through trial and error, can they be singled out and memorised as useful. Such reflexes cannot be found in any other way, because we cannot control or influence our nervous activity. This is the case when fortune is created out of misfortune by attempting to prove that mistakes are useful. Surely you remember the famous saying that we learn from our mistakes. It seems that if you do not make mistakes, it is impossible to learn anything.

Of course, one can learn from mistakes, but first, not everyone can learn from mistakes, and second, not all mistakes can one learn from. When a successful action is developed in the trial and error approach (orientation of the first type), it is revealed as successful only by its final outcome: "Aha, this action turned out to be correct." The relationship between this action and the factors that have influenced it, almost always remains unrecognised. However, understanding the relationship between the action and the factors that ensure its successful performance characterises the consciousness of the action. Therefore, even when a learner finds the correct action through trial and error, the action remains unconscious, not understood, because the relationship between this action and its external conditions or factors remains unrealised by the learner. Therefore, such an approach is barely an attempt to make fortune out of misfortune. Of course, the learning process does happen through trial and error, but this is a very unproductive and extremely time-consuming way to learn. In addition, the action developed in such a learning process remains unrealised (unconscious) by the learners.

Moreover, the action developed through trial and error is often not, so to say, the best possible action, and may contain some unnecessary operations. Such an action has been selected only by its outcome, memorised and fixated in its structure when the desired outcome has been achieved. Therefore, the action selected in such a way does not always achieve its desired outcome in the best possible way.

Educational practitioners should realise that the approach of trial and error does not offer the most productive way of learning. A long time ago, for example, the great philosopher Hegel said that in order to teach a baby how to swim, you must throw it into the water. Now, when we teach swimming in schools, no one begins by throwing a child into the water. We teach swimming in quite the opposite way: we teach on land those actions that will be needed in the water. Teaching via Hegel's method is old-fashioned and cannot be used when an action with desired properties has to be developed with learners. Yet, in a number of pedagogical practices where the goal is to develop more subtle actions, the practice of trial and error is still pursued.

What are the results of such a learning process? We call it spontaneous learning, because a significant part of such a learning process happens uncontrollably and remains unconscious, not realised by the learners. This does not mean the whole learning process is totally unconscious and not realised by learners, though. The learning process may be controlled by the learners, at least by its outcome and at some points of this process. The result of such a spontaneous process is that in a

group of students, there are always vast differences or variations in learner academic achievement. If you plot a graph of the students' achievements, you will get a wide range of achievements: there are many underachieving students, some mediocrely achieving, some students with an average performance and then a steep fall when you approach the number of high-achieving students (shifted Gaussian curve).

Interesting to note is that the students who achieve either excellent or average results do not achieve similar results all the time. We always observe variations in the quality of the achieved learning outcomes and the actions are very sensitive to any changes in the conditions of the actions. Not only environmental factors may influence students' performance of the action and its final outcome, but also the unfavourable state of the learner (fatigue, illness, dejection, etc.) or, quite the opposite, emotional uplift, may affect the development and subsequent use of their skills. Moreover, the learner himself usually cannot explain why he, for example, is performing the action today differently than he performed it previously. Only when there is a big difference in the conditions of the action may the learner provide an explanation: for example, poor lighting or feeling unwell may prevent him from performing the action properly. However, this happens only in some cases, for in most, the learner cannot identify the reasons why he performs the action differently. This is because the action has been developed unconsciously, without being realised by the learners who observe the outcome, which may not be as good today as it was yesterday. The learners cannot identify whether the influence of external environmental factors or something else prevented them from performing the action properly.

To summarise, the action developed with the orientation of the first type is very sensitive to all sorts of changes in various factors, to all sorts of interferences. In addition, actions may influence one another. This is called the phenomenon of the co-influence of actions. Such a co-influence happens in the learning process when learners transfer from one subject to another. If learners are engaged in learning one subject, they may find it difficult to switch to another subject. Why does this happen? Because there is no precise, subtle distinction between actions and they remain undiscovered and unrelated to each other. Therefore, one action can hinder another. This is because these different actions have not been realised by the learners; the actions have been identified only by their outcomes and both their development and performance remain hidden from the learners.

The development of the action with the first type of orientation is time- and effort-consuming and the educational achievements of the learners vary significantly. Different learners need different amounts of time, tools, individual assistance and feedback to master this process. Traditional education explains these variations according to the students' individual abilities. Such an explanation seems to justify everything; however, not everything can be explained by students' abilities. Of course, students' abilities matter, but it is far too easy to explain our unawareness of the psychological grounds of the learning process by referring to students' individual abilities. However, what are these psychological grounds?

The psychological grounds comprise learners' orientations in the learning process. If we would like a learner to master a physical action, we need to clearly identify

the desired outcome of this action, and the sequence of operations to achieve this outcome. The outcome is always present in any action, even in gymnastics or any other form of physical activity, and this outcome has to be divided into the components or units that constitute it. We also need to identify the sequence of the operations in which the outcome's components will be developed. Each operation requires detailed descriptions of each component, and how they will be achieved. In other words, if we create a complete orienting scheme of the physical (or any other) action, then the learners will be able to perform this action in a totally different way.

The appropriation of a complete orienting basis of an action implies that mistakes should not happen in the learning process. At the beginning, a learner moves slowly from one unit of the action to another, from one operation to another, making a stop every time he transfers to the next operation to orient him/herself in the small environment of the next consequent unit of the action. Still, the learner follows the complete orientation scheme that we have created and suggested for use. In doing so, we create the most favourable and beneficial for the student learning process; therefore, unnecessary trials and mistakes should not happen. The learning activity becomes conscious, because each unit of the activity is related to and is performed under its own previously identified conditions. There are almost no variations among the students' educational achievements, because both weak and strong students achieve the learning activity's desired outcome. Of course, stronger students can master the action faster than weaker students, who perform the action slowly, so it takes longer for them to achieve the desired outcome. Yet, even weak students achieve the desired learning outcome in the end.

A typical example of such a process is teaching young children to write. Usually this process starts with teaching children how to write the individual elements of letters in lined exercise books. The learners are typically presented with an element of the letter and are asked to draw this element. The learners do so via trial and error; this process can take a long time until, eventually, the learners are able to draw the suggested element. As you know, this kind of teaching is highly ineffective. Interestingly, teachers usually check how students write letters in the first years of primary school, and then they believe that the learners have already mastered writing. However, students' ability to write letters varies significantly and only a small percentage of students are able to write letters correctly and develop good handwriting.

I have studied many ways of teaching writing and I believe that the Czech method is of particular interest. In this method, a learner is given a large sheet of paper divided into eight equal, very wide rows. The child is then given an element of the letter—for example, a line with a hook—to draw. Since the row is very wide, all deviations in the child's writing are highly visible. Therefore, the child can easily notice these deviations and correct them. Then the width of the row is reduced by half and the same procedure is repeated. After the child has achieved good results on smaller rows, the width of the rows is again reduced by half, though the size or element of the letter is still twice as big as its normal size—the size we start teaching writing. By reducing the width of the row by half again, the normal size of the letters is achieved.

By following this method, the children learn to write letters in 2–3 weeks, and thereafter write the way they have been taught, correctly and nicely, although this method employs the orientation of the first type—incomplete. First, the students use the trial and error approach when learning how to write letters. Second, they develop the skill of writing letters, though this skill is rather narrow: the children learn to write letters and nothing else. The learners still find it extremely difficult to perform such correct writing when they start writing words (several letters together) and sentences. Therefore, the skill of writing letters, developed with learners previously, has very few areas of application and the learning process with the orientation of the first type remains unconscious, with a narrow area of application.

Let us have a look at the learning process with the second type of orientation−complete and provided by the teacher. We examined this process together with my Ph.D. students at the time, when the first-graders were learning to write in the exercise books with three horizontal and oblique lines (Fig. 7.1).

We found that in order to write such a simple element as a line with a hook, a student received eight different instructions; even so, many essential instructions were still missing. It turned out that in some places, the element should not follow the oblique line, which was essential for correctly writing a letter. Then, the lower point of the hook had to touch the line, but where? So, the teacher gave the students different instructions and since a compete orientation had not been developed, some instructions were missing.

We suggested the following: we introduced the most important points of every letter and the child learned to mark these points on paper with dots first, and then connect those dots with a line. By following this method, the process of learning to write happened faster: first the child marked the important points of the letter with dots on the paper and explained why these dots were made in these particular places. Then the child connected the dots with a line to write a letter. Later, the child

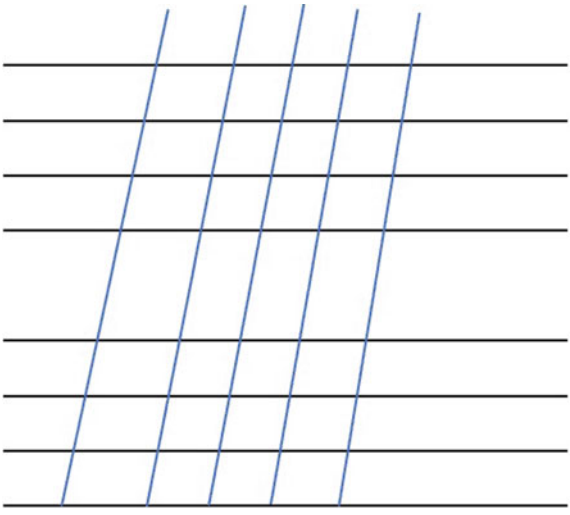

Fig. 7.1 Lined sheets in the exercise books

was asked to make the dots on the paper only in his/her mind and connect these imaginary dots with a line. Through this method, the child gradually mastered the orienting basis of this action and was able to perform the action correctly on the first attempt.

This is a completely different way to learn to write, which leads to quite different learning outcomes. First, all students master the process of learning to write; the learning happens faster without many mistakes and the students are able to transfer their skills when learning to write other unfamiliar letters, even letters from other alphabets, such as those from the Latin, Armenian, Georgian and Arabic alphabets. The students are able to follow the method of placing dots in the most important points of the letters in any alphabet. The most difficult task is to identify these important points in the letters of various alphabets; therefore, the transfer of this method can be complicated. Still, we observed that the students could use this method independently, which did not happen when learning with the first type of orientation.

Another example—from the research of Zoya Reshetova—is about teaching to work with metal-cutting machines. In the control class, the learning process was conducted in a traditional way: the teacher showed how to use the machine and the students were supposed to repeat the teacher's actions. The students tried their best to imitate the teacher's actions, but it took a very long time to learn how to do so. In the target class, the teacher wrote on an orienting card all the necessary instructions: how to use the metal-cutting machine, insert the cutting tool, set up the cutting mode, cut the metal precisely in the required place, etc. Before cutting, marks were made on the piece of metal which indicated where the metal had to be cut, and the students learned how to cut by proceeding from one mark to another. It turned out that by following such a method, all students (even weak students, who were supposed to be expelled from the vocational programme, because they could not carve the simplest bolt) accomplished the task on the very first attempt. Their work was not absolutely perfect, but it was of satisfactory quality and generally acceptable.

Another similar example is from a vocational class in a secondary school. The students were supposed to learn how to use a bow saw, wherein the handles are used to rotate the blade, while a student holds the bow. By doing so, the saw is suspended, and the wood is cut with the saw's lower edge. Because the student looks from above, he can see only the top edge of the saw and he cannot control the movement of the saw in the cut. This is a very complicated task, learning how to saw properly. Additionally, the students must first mount the board that has to be cut on the crafting table, by using a wooden piston that presses the board to the wall of the crafting table. Such an easy task to mount the board on the crafting table turned out to be very difficult for the students. The learners were asked to mount the board so that it was stable but not too tight, so that the board would not crack. How were they to do so? We saw that the students spent much time just mounting the board. Some students even managed to break the crafting table. After a long time, the students found the right strength to mount the board on the crafting table, so that the board was stable enough. They did so through trial and error.

A teacher suggested measuring the pressure needed to mount the board. He made a device that measured the pressure needed to mount the board properly and identified

that a minimum pressure of approximately 57 kg/cm^2 was required to mount the board on the crafting table. He asked the students to follow the arrow on the device while they screwed in the bolt. When the arrow reached the number 57, they were to stop. To assist the sawing process, the teacher made marks on each edge of the board, showing the line the students were to follow. In addition, he attached two iron rods to these marks and connected them to a wire, a light bulb and a battery. When the student sawed in a straight line and did not touch the rods, the light bulb was off; if the student deviated from the straight line and the saw touched at least one rod, the light bulb immediately turned on. The students got an immediate warning that their cut was not straight, and they had to adjust the saw. By doing so, the students learned to hold the saw in such a direction that the light bulb would not turn on. It took approximately 1.5–2 min for the students to learn how to saw properly and this skill appeared to be stable with them. After that the students could saw well enough without using the rods and the light bulb.

To summarise, if you supply the complete orienting basis of the action, the action is performed correctly by the students from the first attempt and the skills developed during this action are very stable. These skills are developed on the basis of the learner's kinaesthetic position and his/her muscular sensitivity. How can this muscular sensitivity be developed? Imagine a monkey who does not have any theoretical understanding of this process. The monkey jumps, runs and grabs, and only on the basis of fine kinaesthetic or muscular sensitivity it is able to develop successful movements. After a long period in the process of natural selection, the kinaesthetic patterns of movements are developed within monkeys. If a movement does not receive reinforcement as correct, it is replaced with another movement. If a movement does receive reinforcement as correct, it is fixated as the kinaesthetic movement pattern and all further movements are performed according to this pattern.

How can this explain the teaching process in the vocational classes with the students who were learning to saw? The control class was exposed to traditional teaching: the students were shown how to perform the action, and then they had to repeat the teacher's actions. In the target class, the students used the complete orienting basis of the action. In the control class the strong students performed more successful operations than unsuccessful; however, the majority of students performed more unsuccessful operations than successful ones. In the target class, meanwhile, approximately 92% of all operations performed by the students were successful and the difference between the performance of the strong and weak students was insignificant. Therefore, the students' educational achievements were very similar. In addition, the "worst" student in the target class performed better than the "best" student of the control class.

The most unexpected result was the fact that the teachers who were teaching the students in the target and control classes could perform only approximately 65% of the operations correctly. Of course, such level of mastery was much higher then the level of mastery of the students in the control class, but the students in the target class clearly outperformed their teachers.

The time required to develop such skills with the students in the target and control classes was also different. The students who used the trial and error method took much

more time to learn to saw correctly than the students in the target class, who learned how to saw in 1.5–2 min by using the controlling devices. However, it turned out that the developed kinaesthetic pattern of movement may grow weaker with time and then the learners may need to repeat sawing with the controlling devices to reinforce the pattern. After that, the correct kinaesthetic pattern of movement is established completely. What is important is that the students in the target class developed a very positive attitude towards the process of learning—they learned to perform the activity not through trial and error, but by engaging in the learning process consciously. They also applied their positive attitude to practical lessons, because they could make connections between theory and practice.

To conclude, the learning processes in the target and control classes were totally different. The skills developed by the students in the control class who used the trial and error approach had very few areas of application. Such skills are considered the simplest form of learning, and are opposed to knowledge. However, these skills are also the simplest form of learning, because they are being taught in the simplest way or, to say it correctly, they are not being taught at all, although the students attempt to learn on their own through trial and error. Still, if we develop skills with learners consciously, the duality between skills and knowledge disappears.

Now, a few essential points about the development process of a new activity. How does this process happen and what changes does it cause in the orienting and the executive parts of the action? In the orienting part, the activity is divided into units. The learner proceeds in the following way: first, he gets familiar with the situation in the nearest unit, then performs the activity in this unit of the action, pauses, gets familiar with the situation in the next unit, performs the action in this unit and pauses again, to get familiar with the situation in the following unit to perform the action in this unit thereafter. This cycle repeats itself until the action has been performed by the learner in all units of the action. When the learner performs the same action again, the units of the action eventually merge into one flow. This happens, because the learner does not need to pause to get familiar with the situation in the next unit, as he quickly recognises the situation and performs the action in this unit at once. Yet because the situation in the following unit is already familiar to the learner, he starts getting ready to perform the situation in the following unit, while he is performing the situation in the previous unit. Therefore, when the learner approaches the next unit of the action, he is ready to perform the action in this unit. The learner does not need to pause before this unit and with time, he stops pausing at all, just slowing his action performance before transferring to the next unit. In the end, the action starts to flow as one continuous process. The action is performed according to the recognised image of the situation. The learner controls this action's flow by comparing the actual action with the sense of the right flow of the action he or she developed earlier. The learner does this automatically, without too much thinking; he or she just compares the actual action flow with the image of the action he/she has developed previously. Physiologists call this validating or controlling the performance of the action. This process leads to automation of the action: first the formation of bigger units of the action (not immediately, but gradually), and then merging of all units into one continuous flow.

When the action begins to flow as one indivisible process, indicators of the action, such as the tempo and rhythm, become important. As a matter of fact, the action can be performed at a different speed in its different units. The speed of the action performance is the rhythm of the action and it can vary. At first, the rhythm of the action is unimportant, but after the action has been mastered by the learner, the rhythm has to correspond to the required parameters and the learner has to work to improve the tempo of the complete action.