

Score-Learning as Creative Problem-Solving: A Basis for Diverse Performances

Charise Hastings
Tallahassee, FL, USA
cyhastings@gmail.com

Studies of how musicians learn scores often draw on literature from cognitive psychology that compares differences between experts and novices, in their level of conscious motor control, their ability to arrange information into groups or chunks, and their skill in recognizing underlying structures (Chaffin, Imreh, Lemieux and Chen 2003, Lane 2006, Lehmann 1997, Williamon, Valentine and Valentine 2002). Recent studies have begun to investigate how experts engage in creative thinking that leads to innovations in their field. A dominant question is whether creativity is the result of ordinary or extraordinary thinking; and whether creativity can be understood as a continuation of prior knowledge, or a breaking away from it.

Robert Weisberg argues that creative thinking can happen through ordinary, business-as-usual means of problem-solving, and that decisive breaks with past knowledge are not a requirement for innovation. For example, he argues that the discovery of the double helix structure for DNA strands shows evidence of logical thinking, rather than a sudden flash of insight. James Watson and Francis Crick began with an assumption that the DNA was a helix, then, drawing on research by their contemporaries, used heuristics such as working backwards from their assumed goal to model the structure (Weisberg 2006, 148, 20-32). Similarly, Weisberg shows that Pablo Picasso's conception for *Guernica* [PP2] can be seen in earlier works and sketches, rather than exhibiting a break from previous styles. One instance is *Minotauromachy*, an etching Picasso did two years earlier, which has a number of the same subjects as *Guernica* such as flowers, birds, a bull, a raised horse's head, and a sword, as well as a similar spatial

organization (Weisberg 2006, 42-47).

A model of creative thinking through ordinary, business-as-usual processes serves as the basis for my research on how musicians learn. Creative thinking happens when someone attempts to solve a novel problem. [PP3] A problem is novel if that person hasn't encountered it before. It's possible that other people have already solved this problem, in which case the person's solution is unlikely to have much impact in society. But the thought process is still considered to be an instance of creative thinking for that person. A problem is defined as being in an undesirable state, and not immediately knowing how to change that state to something more desirable. The problem space represents one's initial state, the goal state, and all the steps in between, as well as relevant information and means of progressing from one step to the next.

The first stage of solving a problem is defining or representing the problem. [PP4] The problem may be well-defined or ill-defined. Well-defined problems often have algorithms, like math formulas, that guarantee the right answer. These problems require no creativity, only the proper knowledge. An ill-defined problem is where the potential for creative thinking resides, because an essential structural element of the problem is unclear, such as the goal itself or the steps leading to the goal. For instance, when musicians pick up a score they've never played before, they're faced with an ill-defined problem of how to play this piece in a satisfactory way. They may have ideas about some of the steps, but the process isn't laid out clearly, and there are multiple solutions for achieving the same goal.

The second stage is attempting to match the problem with one's knowledge and experience. Have you already solved this problem, or one like it? If so, then an existing solution can be mapped onto the present scenario, and the problem is solved. These solutions are called strong methods because they can make use of information specific to that problem. Strong

methods find an analogous situation that has a similar underlying structure to the current problem. In learning music, if there is a section of music that is causing difficulties, the musician might realize that it's very similar to something else they've played before. If there are enough structural similarities between those two passages, they can apply the technique from the previously learned piece to the current one. An example would be using one's experience of playing Chopin's etudes to learn parts of Chopin's longer pieces.

When a strong method isn't available, the final step is to resort to heuristic methods such as planning, trial and error, or means-end analysis (Weisberg and Reeves 2013, 534). At this point one is relying on general rules of logic and deduction to solve the problem. Each heuristic has its own procedure, but the first steps are usually to add constraints to reduce the problem space, and to set up subgoals to work out the solution step by step.

For instance, some pianists might have problems with a fast scale passage, wondering what fingering to use, as in this example from Chopin's First Ballade (m. 250-253). An exhaustive approach of trying out every single fingering would be impractical, as the problem space is too large to search by trial and error or random guessing. To reduce the size of the problem space, the pianist will introduce constraints, such as eliminating non-sequential fingerings, and making sure the scale ends on a strong finger rather than a weak one. Simply by adding these two constraints, the problem space is reduced to a size that can be explored in greater depth. Pianists might then apply a heuristic like working backwards, and play the last four notes to find the fingering that will give them the best *sforzando* effect (m. 251-252, a). Then they can add the previous notes, a few at a time, to find the fingering to support this goal (mm. 250-251, b-e). The heuristic of working backwards reduces the problem space to only a few choices, so that each option can be investigated in depth.

Method

Music researchers study how people learn music by conducting structured and semi-structured interviews with expert and student musicians. They might ask them to keep journals of their practicing, or record their practice sessions (Green 2012, Hallum et al. 2012, Miklaszewski 1995). I conducted semi-structured interviews with thirteen piano teachers about their approach to teaching the coda of Frederic Chopin's First Ballade in G Minor. I decided to interview teachers, because they are accustomed to verbalizing the learning process, and are constantly evaluating how students progress. I chose the First Ballade because I've played it myself, and it is a popular work that is performed by pianists of all ages, from children to professionals. Since it's a longer piece with different sections I decided to focus on the coda, which has notorious physical difficulties that require pianists to make conscious decisions about their technique and musical goals. My purpose in the interviews was to understand how different pianists might work through the ill-defined problems of the coda and thus exhibit creative thinking. I was especially interested to learn how pianists understand the relationship between their technical and interpretive choices.

Here are some sample questions I asked. [PP5] I usually started by finding out what whether they thought the Ballade was one of Chopin's masterpieces or not, because Chopin has been criticized for not having a good grasp of larger forms. Chopin is also known for having multiple editions of his scores, so I wanted to know if teachers preferred one edition over another. Then I tried to get a sense of how they interpreted the score indications, because there are different schools of thought about what some of the expressive markings mean. Finally, if the teacher hadn't already brought up some of the physical challenges, I asked about problems that I remembered having while I was learning the piece, such as playing leaps accurately and feeling

tension in my arms.

These were some of the questions I tried to keep in mind, but I also wanted the teachers to volunteer their thoughts freely on the piece, so I didn't always ask everyone each question. I recorded the interviews with audio and video, transcribed them, and then analyzed them for instances of strong and weak methods of problem-solving. I took a qualitative rather than a quantitative approach to the interviews, so I've treated each interview as a separate case study rather than trying to find statistical comparisons between them. I identify the teachers by initials to preserve their anonymity.

Results

I originally assumed that the main goal could be represented as, "How does one play this piece well?" [PP6] While this was certainly one aspect, the teachers tended to have a somewhat different focus, since they were guiding someone else to learn it rather than playing it themselves. Teachers were mainly concerned about how to raise the students' awareness of three important elements: the score, their sound, and their physical motions. An additional goal was finding appropriate techniques for learning and performing this piece up to tempo. But all these aims underlie a deeper goal, one that is apropos to musicians at all levels and not just students. That goal is to play in a way that sounds fresh and sincere.

All these problems are ill-defined, and subject to a variety of solutions and steps. The size of the problem space for each of these goals is so large that problem-solving is necessary to achieve satisfactory solutions. A piece like the First Ballade, which takes months to learn, is too complex to apply a single, all-encompassing solution to it. Even teachers who have strong methods of problem-solving and have performed the piece themselves cannot rely solely on their strong approach, because the students are learning the piece themselves through weak heuristic

methods. Teachers thus have to help students by reinforcing and correcting their habits from week to week, and by solving each student's unique set of constraints and obstacles.

Strong Methods

Several teachers told me about strong methods they use for the coda, based on their experience teaching it to numerous students, or on their own playing of the piece. One strong method, described by SH, divides the music into small groups so students can practice moving between hand positions. [PP5] This is an example that he showed me from the beginning of the coda. SH has students play each group in orange brackets, pause, move their hands to the next position, then play the next group. Practicing in small groups allows students to control the shape of each gesture by making a small crescendo towards the accented note, and a decrescendo away from it, using an up-down-up motion in the right hand. SH says, "The shaping leads the feeling of it. The accent happens where the physical release happens." These groupings are based on his sense of the larger phrase structure and pulse. For instance, in the first subphrase he groups according to the written meter, so that the pulse of the written meter off-sets the accented notes; but in the second subphrase he changes the groups to start on the upbeat, making the accents line up with the perceived meter. Even if the students don't realize it at the time, they are learning a certain way of expressing the metrical tension by these groupings. This strong method helps students start to hear phrase shapes and to see notes in combined units rather than individually. It raises students' awareness of the score, particularly the importance of the meter and the accents; and it raises their awareness of the relationship between their physical motions and the sound.

A second method, presented in most detail by by ST, focuses on choreography. [PP8] He points out that the beginning of the coda is difficult because the motions need to be different for each hand. His general approach to teaching a passage like this is to "group the pattern into a

larger, graceful motion." For the left hand, then, instead of a back and forth motion from bass to chord, ST describes a "down-over-up" motion from the bass note to the chord. For the right hand, it's moving "up-down" and "up-up-down". Students, he says, have trouble because they tend to "do the same motion with both hands at the same time." He compares this kind of poor technique to being in a straight jacket. He says, "Until [the students] are loose, you can't even see what someone's capable of." He trains the students to choreograph their hands individually into this more intricate pattern, because these graceful motions will then free them to play accurately and expressively.

Two other teachers, LC and RM, also mention choreography for this passage, but they emphasize different aspects. LC, who has performed the piece, explains that the left hand motion in the bass is circular, and you have to imagine making "a circle under the piano"; although at a fast speed, the motion will actually be down and up, and the fingers will have to stay very close to the keys. In addition to imagining the circular movement, the students must also grab the chords with their fingers, using a very light, scratching kind of gesture. The grabbing motion will give them accuracy and control.

RM comments that the hands are moving in different directions, as ST does, and he additionally mentions that the hands have different rhythms as well--right-hand eighth notes versus left-hand quarter notes. Because the left hand is playing a slower rhythm, it's apt to get stuck in the key. He says, "If you're into the key too much, you're never going to be able to negotiate this." So RM has students focus on releasing as soon as they've played the note, so they can free their hand to move.

All three teachers suggest choreography as a way for students to learn this passage, but they concentrate on slightly different motions. This is an example of finding different steps

through the problem space to the same general solution, which is to play accurately and expressively using choreography.

The third strong method is using varied rhythms, and this is not specific to the coda but can be applied in many contexts. [PP9] WL, who has played the Ballade, describes this method as what her teacher taught her, and what she passes on to her students now. One example she gave me is from the Chopin Etude in C-sharp Minor. Each set of four sixteenth notes is made into a group, and the student practices cycling through a set of holding each note of the group longer than the others. The goal is to be able to play the passage in all four rhythms with precision near performance tempo. Students might work on these rhythms for six to eight weeks as part of their practice regimen. WL explains that this method builds strength and endurance, and it instills a rock-solid, steel rhythmic framework, which the student will later be able to deviate from when using rubato or other expressive features. She says, "Freedom is only measured against a standard; you can't have freedom without discipline." In the Ballade coda, for instance, the off-beat accents can be an important expressive feature, but those off-beats can only exist if the base metric pulse is there.

Weak Methods

When it comes to using weak heuristics, some methods are more comprehensive than others. One of the most effective heuristic methods is means-end analysis. [PP10] This involves having a sense of what your goal is, and then working out the means to get there. There are four repeatable steps for this heuristic (Novick and Bassock 2005). First, identify the difference between your current state and your goal state. Second, find an operator that will remove or reduce the difference. Third, try to apply that operator. If something stops you from applying it, then set a subgoal to remove the obstacle. These steps can be repeated until you reach your goal.

For example, you want to play the coda at a certain tempo. The obvious operator is to move your hands faster. But, if you do that you start missing notes and feeling tension in your arms. So you create a subgoal of being able to play the notes accurately without tension. This subgoal still leaves a fairly large problem space, so it may have to be further divided into other subgoals. You may have to break the coda down into smaller segments and set a goal to simply play two measures at a time accurately without tension, rather than the whole coda at once.

With a means-end heuristic you can get to your goal eventually, though not as efficiently as with a strong method, which uses steps that are known to work. The advantage of weak methods, though, is that they offer more possibilities for finding different solutions, and are therefore an integral part of creative thinking. Weisberg (2006) has argued that innovations in many fields often come through a combination of strong and weak methods of problem-solving.

The main goal for learning a piece, as I said before, is playing it in a way that's fresh and true to oneself. How do teachers guide students in this direction using weak methods? One teacher, KL, contrasts fresh playing with someone trying to copy a recording. [PP11] He says that with this Ballade especially, students are prone to having strong ideas from someone else's performance of it, and they end up unconsciously imitating that recording. So he tries to challenge everything they do, to raise their awareness of what the score says, and of the decisions they make. This operator is a complicated process, so the main ways in which teachers try to guide students is to bring to their attention the details of the score, the sound that they produce, and their physical technique. Each of these subgoals can be achieved through heuristic methods.

One of the first steps in heuristic problem-solving is reducing the size of the problem space by adding constraints, or tightening existing ones. [PP12] In fact, a large part of what teachers do could be described as reconfiguring student's constraints, that is, removing some of

their technical and mental limitations, and making them aware of other boundaries based on performing traditions. The first subgoal of becoming more aware of the score is achieved by the relatively straightforward heuristic of reducing the problem space by imposing constraints. The markings in the score act as a constraint, and students are trained to notice all these markings.

Of course, it's not enough to simply recognize an accent or a *sforzando*; there's a wealth of performing traditions that the teacher passes on to the student about the proper way to interpret these markings. For example, in Chopin's scores teachers told me that accents should never be harsh or percussive, even when they are outlining the melody, as in this example. The accented notes have to be nuanced: one teacher quotes Chopin as saying, "Don't make the piano sound like a barking dog." As we saw earlier, the accents can also be interpreted as a way to play groups of notes, as SH described for mm. 208-212.

The most controversial marking in the coda is probably Chopin's pedaling, because of the older style of notation using a "snowflake" to indicate the pedal release (highlighted in orange), as opposed to the modern line with the wedge showing when to change the pedal (highlighted in blue). The problem with the snowflake marking is that if you follow it literally on a modern piano, the music will sound like hiccups, because the pedal cuts off the piano's resonance completely. Not one teacher told me they follow the pedaling literally, but they did express a wide variety of ideas about how to interpret the pedal markings. Here are some examples, from more literal to less literal.

HG: "Chopin was always very meticulous about his pedal markings, but the snowflake marking means, 'Be clear and use pedal if you have to, as inconspicuously as possible.'" HD: "Pedaling is *impossible* to notate, in some ways, because it changes from piano to piano, from room to room, and from person to person. We have to understand what our fingers are doing, and

then use the pedal to help that. You should try Chopin's pedaling, because it brings out different voicings. And then, if it's not working for you, do something different." SH: "With Chopin's pedaling, there's no absolute answer. I kind of go from a sense of Chopin's sound. If you try these pedalings on Chopin's piano, it actually works pretty well. But doing something like this on our pianos makes the music sound really hoppy." NG: "Chopin's pedaling markings are a problem. Some of this you just have to use your own judgment." As we can see, teachers draw students' attention to the details of the score, but the actual constraints that the score appears to delineate will vary depending on the teacher.

The second subgoal, raising awareness of the student's sound, has to do with teaching students to listen to what they produce, but also to have an idea of the kind of sound they want *before* they play. A common heuristic for deciding how to shape a phrase, for instance, is planning. [PP13] With planning, you create an abstracted version of the problem by omitting certain details, solve the simplified problem, then transfer the solution back to the original problem. Planning isn't guaranteed to work, but it can help you explore different possibilities or even lead to an outcome that wasn't anticipated.

To decide how to phrase passages in the coda, several teachers talked about blocking chords. [PP14] HG describes the process in some detail. She suggests that her students extract the underlying harmonic progression of a passage by blocking the chords, and play the chords slowly and liberally, as though they are playing a nocturne, "so [they are] always thinking about the lyrical and the shaping first." Then, when they play the phrase as written, they know where they want the phrase to go, so it won't just "sound like empty technique." She admits that students sometimes have a hard time abstracting the chords, so she will play the blocked chords while they play the phrase as written. Planning helps students integrate expression with their

physical movements.

The third subgoal, raising awareness of physical gestures, can be achieved with means-end analysis, which, as I mentioned earlier, involves creating subgoals and applying operators to reduce the difference between one's current state and the goal state. When it comes to technique, teachers often use a combination of broad and specific ideas to aid a student facing difficulties. GR says that his "general philosophy is to find the maximum comfort and efficiency and ease in what you're doing, and then your effort can be on artistic questions rather than physical ones." This constraint begins to reduce the problem space of finding appropriate physical movements. [PP15]

From there, each passage of a piece can constitute a subgoal. Some phrases will pose no difficulty for the student; but others will have to be further analyzed to solve a particular problem. An example of a physical problem in the phrase under discussion might be shifting the right hand smoothly between the thumb and fifth finger. While making this transition students might glitch notes or accent wrong pitches. A subgoal is then set to play the phrase smoothly; based on his expertise, GR knows that an arpeggio technique is most effective for this passage, which would mean either a rotating or an up-down wrist motion. The problem space is now narrowed down to two choices. He asks the student to practice both techniques, then says, "Now don't think about it; just play," and sees which motion the student's body will naturally choose. GR applies principles of the somatic educational system of movement developed by Moshe Feldenkrais in the twentieth century, which assumes that one's body will automatically choose the path of least resistance (which, in this case, means the physical technique that will fit a particular student's body most comfortably). The principles of the Feldenkrais method thus add another constraint that is in keeping with the higher-level constraint of finding motions that

contribute to maximum ease and efficiency.

The three heuristic processes I've described for solving problems in these four measures--reducing the problem space, planning, and means-end analysis--might seem like laborious procedures, but in practice teachers often arrive at solutions in a matter of seconds, usually by observing and listening closely to what the student is doing. [PP16] Teachers may not even be conscious their thought processes of problem-solving. By articulating these processes as heuristics, we can begin to see how students might learn to problem-solve for themselves. They can apply the same heuristics to the score that their teachers are using, recognizing that there is no single, correct heuristic for a difficult passage.

Conclusion

I observed that the relationship between technique and interpretation is more complicated than one might be led to believe. A common belief, which several teachers echoed, is that technique should aid one's interpretation, rather than define it. The implication is that if you can find a way of playing that gives you the greatest amount of freedom and ease, you can then be as expressive as your imagination will allow you to be, especially during live performances. But in a physically challenging passage like the coda of the First Ballade, students have to put in a lot of work to even express one interpretation well. Some of the strong methods especially seem to "bake in" the phrase shapes during the time of practicing repetitive physical movements, suggesting to me that, if you wanted to later change the way you shape the phrase, you might have to start over with the way you group the notes and practice the physical gestures.

This "baking in" process of learning technique and interpretation together may be dependent on the physical difficulty of the passage, so one of the future directions of this research will be to consider how teachers approach less technically challenging music, such as

the first and second themes of the G Minor Ballade.

Teachers' use of both strong and weak methods for learning music shows that a score represents a novel problem for each person encountering it for the first time. The problem is ill-defined, as there are numerous paths to various solutions within the same problem space, depending on the teachers' and students' constraints and goals. Such a non-linear process of learning is a trademark of creative thinking.

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