A “polyagogic” approach to the use of the computer in music pedagogy

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The topic this morning is the use of electronics, that is, in effect, the use of the computer, in the pedagogy of the arts. More specifically I will speak of the use of the computer with regard to music pedagogy. I want to take as a case in point the standpoint of the composer Iannis Xenakis with regard to the use of the computer in music pedagogy and music composition. Where does the use of the computer fit in with regard to Xenakis' approach to the teaching of music more generally and, in particular, to his approach to the pedagogy of music composition? First, let us see how Xenakis himself was educated.

Xenakis had an education not in music, but as an engineer. He studied as a young man at the Polytechnic School in Athens. He had little formal education in music beyond some basic music lessons in Greece, although once in France, he tried to study musical composition with Honegger, Milhaud, Nadia Boulanger and Messiaen. It was Messiaen who advised him that he did not need the usual education of the music conservatory, but that his would be a different musical path. Xenakis, once he entered France, found employment working with the great architect, Le Corbusier. He was initially hired for his engineering skills. He learned to be an architect while working for Le Corbusier, not by going to architecture school.

Perhaps, because of Xenakis' own singular path towards becoming a composer and architect, which did not pass by music school or architecture school, Xenakis developed a strong antipathy towards conventional academic approaches of teaching the arts. He believed that the academic way of teaching music, for example, which focused on traditional disciplines such as solfège, counterpoint, harmony, music analysis, etc. tended to create conservative composers more directed towards recreating the past in their musical works rather than being openly creative and original with regard to the future of music.

Consequently, Iannis Xenakis proposed that young composers, in general, should not limit their education to traditional musical disciplines as taught in the conservatory. He even questioned whether such a traditional approach was useful at all for stimulating original creativity in a young composer. To the contrary, he felt that young composers should study form and transformation in nature (morphology, palaeontology), form and transformation in science (biology, physics, chemistry) and form and transformation in architecture. In addition, he felt it important that young composers should also study mathematics, acoustics, philosophy, psychology... In short, in order that young composers should discover new approaches to musical form and to the transformation of sound, he felt that they should have at their disposal a large extra-musical education to supplement or even to replace the traditional music conservatory approach.

Xenakis went one step further in his reflections on the musical pedagogy of young composers.
He came up with the idea of developing a computer music system that would be at once a pedagogical as well as compositional tool. In the mid to late 1950s, Xenakis began to compose, perhaps under the influence of his architectural work with Le Corbusier, by first drawing his music as continuously evolving graphic forms. Such orchestra pieces as "Metastasis" and "Pithoprakta" started as graphic scores which

were later transcribed into quasi-traditional notation so as to be playable by a symphony orchestra. Already in the 1950s Xenakis dreamed of a tool that would allow him to enter graphics directly into a machine and to hear the result.
It wasn't until the 1970s when computer technology had evolved sufficiently and when Xenakis had at his disposition a computer music research centre which he called CEMAMu (Centre for the Study of Mathematics and Musical Automatics) that he was able to start to work on this compositional and pedagogical tool which he called UPIC (Polyagogic Computer Unit of the CEMAMu).

The UPIC system embodied many of Xenakis' basic ideas about music pedagogy and music composition. First, the name UPIC itself contains the neologism "polyagogic" which has the same root as pedagogic. "Agogos" in Greek has the meaning of a path towards knowledge.
Pedagogy is the teaching of a path towards knowledge for children, or for the young more generally, while "polyagogic" implies many paths towards knowledge. The UPIC system was to be a "polyagogic" tool for pedagogy, that is, instead of the "one way" for all approach of academic musical pedagogy, Xenakis wanted a pedagogic music tool that could work just as well for composers as for adult amateurs of music and also for children. The idea was to develop a system much more general with regard to working with musical sound than traditional musical instruments were capable. The use of the computer and of the UPIC system itself was to provide an open space for musical sound. First of all, Xenakis had the idea that in drawing sound that one might work directly with sonic events in an open musical space as opposed to those events being pre-constrained by a too rigid pre-existing notational system. He was, of course, thinking of notes written in tempered scales in traditional musical staff notation. On the contrary, in the UPIC system, one draws first the geometric macro-form of the music "out of time" and then one decides which frequencies, intensities and timbres to assign to the musical drawings or arcs as they are called when played by the computer "in time". One must decide what duration to assign to the musical page that is drawn. Changing the duration of the page did not change the frequency or pitch of the individual arcs. The frequencies or pitches of the arcs were independent of the duration of the musical page.

The original UPIC system of 1978 was not a real time system, that is, one had to wait a long time for the computer to calculate the sound of the page. In 1987, the first real time version of UPIC was developed which meant that one could draw and then hear the result of the drawing right away. It was at this moment that UPIC could become not just a composition tool for composers, but also a pedagogical "polyagogic" teaching tool for adults and children alike who wanted to learn something not just about music, but about sound more generally.

Xenakis' idea was that drawing was a more direct way of seeing and hearing what sound was. The idea was to draw everything. When you drew a waveform, you could see and hear the timbre it produced. When you drew a curve of intensity, you could see and hear graphically what the traditional music terms of crescendo and decrescendo really meant. If you drew a straight line or arc, you could see and hear a

steady pitch or frequency with certain duration depending on the length of the line drawn. If you drew a slanted line, you heard a sliding tone called a glissando which passed through all intermediate pitches from the start to the end point of the arc.
Depending on how long the glissando was and at what angle you drew it, you could also see and hear the speed of the glissando.

Learning the relation between the graphic representation of a different musical parameter and its sonic result was a veritable pedagogy of musical acoustics and psychoacoustics. With UPIC, one was astonished to hear the very tight relation between frequency and rhythm, for example. Playing a short sample of $1/10^{th}$ of a second of sound as a waveform at a very low frequency, for example, 3 hertz, that is 3 repetitions of the waveform per second, was the same for the ear as hearing the rhythm of a triplet, that is, 3 iterations in the time of 1 second. There was also the tight relation between intensity and rhythm to discover as well. Drawing an intensity curve and applying it to a very short duration produced a rhythm while the same curve applied to a very long sound duration resulted in an intensity variation of loud and soft. I could give many other examples, but the point is that Xenakis wanted to open musical pedagogy via his “polyagogic” UPIC system to a new way of introducing, not just composers, but non-musicians, children and adults both, to the acoustics and psychoacoustics of sound first and foremost without prejudicing what was music or not by the introduction of traditional notation and traditional instruments, both already associated with a certain historical musical practice.

It is interesting to note that in my experience introducing UPIC to children in the 1990s that young children, that is 5 to 7 years of age, could draw and listen to what they had drawn with UPIC without deciding or seeming to care whether their result was “music” or not. On the other hand, 10 to 12 year olds were already concerned if what they had drawn was “music” or not and asked me how to draw Mozart with the UPIC system. It would appear that despite all attempts to make the UPIC system as open and neutral as possible by Xenakis that even the rudimentary musical education of the grade school level had already made children afraid of “making a mistake” while drawing. It was difficult to convince some of these children that there was not just one way to draw with UPIC, not one “right way”, but many ways and that the idea of UPIC was that each person should find his unique way with the system, that is, each should find what was interesting and original for him or her.

Of course, Xenakis was not so naïve so as to think that his UPIC system was going to turn all amateur children and adults into “composers”, but he did have the idea that a “polyagogic” computer music approach to musical pedagogy was much more likely to stimulate the individual curiosity and creativity of composers and amateurs alike, much more than a traditional conservatory approach. UPIC was a unique and original use of the computer as a pedagogic music tool that allowed composers and amateurs alike to learn about how to represent music graphically as an abstract structure drawn in an open geometric space “out of time”. Hearing a drawing “in time” after drawing it “out of time” effectively separated the “out of

time” operation of creating an abstract geometrical structure from the “in time” operation of hearing the resulting musical form as sound. The drawing approach to musical form also allowed gesture coming from the body of the composer to be incorporated into the result by creating a connection between the hand drawing of the arc and the sound heard by the ear when the page was played.

The last version of the UPIC system for the Windows system was complete by 1993. What future was there for Xenakian “polyagogic” pedagogy after that? From 1993 to 2007, while directing the Ateliers UPIC, renamed CCMIX in 2000, I developed an 8 month course in "Computer Music and Composition" for young composers who were in residency attending lectures and composing new works. The content of these lectures included not only many subjects directly relevant to computer music education as taught by such experts in the field as Curtis Roads ("Computer Music Tutorial"), Trevor Wishart ("CDP system") and Carla Scaletti ("Kyma System"), but there was also a course taught by myself where Xenakis' own book "Formalized Music" was a major starting off text and that was followed, later in the year, by lectures that I gave that focused on the contemporary mathematics and physics of "Chaos Theory" as well as the philosophy, psychology and physics of different approaches to space and time.
In all of these courses, mine as well as those of the other professors, the use of the computer as pedagogic tool was primordial. Every professor’s theoretical teaching in their lectures was accompanied by a computer application that allowed the ideas taught in the lectures to be tested and applied by the student composers in their individual studio time in CCMIX’s pedagogy studio.

Therefore, the approach in these courses was highly multi-disciplinary and students were often introduced to subjects rather far from music, so as to stimulate their individual creativity in the domains of computer music and composition, more generally speaking. A very important part of these courses was the application of theoretical and technical course work to individual composition. Individual studio time was ample so that students could compose new works without prejudicing which computer tools they used (many besides Xenakis' UPIC system were introduced) and which theoretical/aesthetical approaches to music composition were to be favored by students.

Xenakis did not want to have disciples, that is, he did not want imitators; on the contrary he valued that each composer should find their own original path. As a consequence, my Xenakian “polyagogic” pedagogy was not oriented towards making students follow the compositional approach of Xenakis, but rather to having the students ask penetrating questions of themselves as to "what is music" and "what is composition" for them. In this sense, Xenakian “polyagogic” pedagogy is a method of self questioning for the composer about the “what of music” and the “why of composition”, a path towards finding an individual and unique compositional voice as opposed to the giving of a specific set of answers or technical methods as to how to compose or how to approach music theory by a “master”. Just as with the UPIC system, the idea of such a musical pedagogy is that there are many paths to musical composition and to musical self knowledge, not just one. The uniqueness of each young composer’s musical voice to be found is

altogether another type of “oneness” than the “oneness” of the unique “truth” sometimes taught in certain rigid academies of music that pretend that there is only one way to learn how to be a composer or even that there is only one correct way to compose.

The broad and open education used in the CCMIX 8 month course was meant to stimulate composers' imaginations and thinking without proposing a definite method of composition or definite answers to questions that finally each composer must answer only for themselves. Stimulation of mind and imagination without influencing the musical result was the approach chosen. Educating and opening minds of young composers to new approaches to composition that might come from domains out of music was done only to give composers the maximum chance to find their own original path, that is, to truly be themselves as composers, to write no one else's music but their own.

It is clear that in Xenakis’ approach to musical pedagogy with the UPIC system and also with my own approach in the “Computer Music and Composition” courses at the CCMIX that the use of the computer as a pedagogical tool was crucial. The computer which is our modern tool, par excellence, is the most general and most open for the teaching of music and other arts because as nothing more than a calculating machine of great speed and flexibility it does not carry with it a specific aesthetical approach or prejudice that comes from past musical tradition or practice. That is not to say that computers do not have their limitations.

I don’t believe, for example, that it is possible to have a computer-based compositional system for music that is completely neutral or fully open as to its musical approach and sonic capability (the UPIC system was quite limited in its own way too). All computer tools, musical ones included, bear the imprint of their programmer. There is no one computer tool for the pedagogy and composition of music today that is, or that can be, no matter how well done, ideal for all composers and for all musical applications. Xenakis developed his own composing tools and, even if he hoped that UPIC could also be useful for others, he did not insist (and neither did I while directing CCMIX) that this one tool, as “polyagogic” as it was, could be sufficiently complete and open for all composers so as to render all other computer music tools useless.

Therefore, my conclusion as to the application of electronics that is, the computer, to musical pedagogy and creation is that having many students/many creators using the computer implies always the need for many computer tools. It is, of course, one of the many reasons that young composers are taught how to program their own applications today in such open graphical environments such as Max MSP, Super Collider, etc.