Creating a Glass Lens – a Metaphor for Learning

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Abstract

The article seeks to answer the following question: is it possible to describe a learning process by describing the process of glass making? The motivation for the article is a game – a quest for metaphorical equivalents in the processes of glass making and learning. I challenge myself to test if the objective of my field of teaching can be used to illustrate a learning process. If I'm lucky, I'll be able to share information and views on both fields simultaneously.

The article is about making a glass lens. A lens is a tool to observe the world with – either close or far. Learning aims to become knowing that can also be seen as a means to explore the world with. Put succinctly: I'm using the glass making process as the metaphor for the learning process and the finished glass lens for knowing – the process and its result. In the article, I will go through the main steps of the glass making process, which includes mixing raw materials, melting, refining, homogenization, casting, annealing, grinding and polishing. Each step in some way comments on certain elements of the learning process and also the realities of teaching.

Keywords: Glass, lenses, metaphors, learning, teaching, knowing, glass making

Creating a glass lens – a metaphor for learning

When teaching, I have noticed that I explain many things with metaphors derived from the world of glass. I have come to wonder if I have slowly brainwashed myself, meaning that after many years of working with glass as a designer, artist and a teacher, I have started to think not only of glass but also in glass. The versatility of the material is such that it feels natural and easy to explain the whole world through it.

Why metaphors? The language of art is metaphorical. Language itself is metaphorical as Lakoff, a linguist, and Johnson, a philosopher, say: "Metaphors as linguistic expressions are possible precisely because there are metaphors in a person's conceptual system." (1980, p. 6). The point of this text is to use the language of art to talk about pedagogy. This article leans more towards my own hands-on experiences as a teacher than pedagogical or philosophical theories, although Lakoff and Johnson (1980), Barnett (2010), Scardamalia and Bereiter (2006) and Kolb (1984) make visits.

Why glass? Glass is a material that never ceases to inspire me. I was originally drawn to its transparency and the fact that through it I saw the light. Literally. The relationship of a see-through material and light is symbiotic: glass becomes perceivable through the reflections and shine on its surface. It is a versatile material in its aesthetics, working methods and history. Glass making can be seen as a mystical process in which dry sand becomes a thick magma-like glowing mass and after air is blown into it, a thin bubble of air or ice is born – a metamorphic material, one could say. The previous description sounds like a reference from a diary of an ecstatic modernist from the 1950s but such mental images are strong and vital. Glass easily mesmerizes people, which I tend to notice every time I take the students out of a classroom and into the glass studio. Fascination can be a central element in awakening the motivation to learn and it in no way prevents critical thinking, doubt or questioning, which I also consider important in learning. At its best, fascination can seed a life-long passion and the curiosity to work and learn more.

But why use glass as a metaphor for learning? Glass is an amorphous (non-crystalline) solid, meaning that its molecular structure is similar to a liquid. It has no particular melting point, unlike metals for example, but it softens gradually as the temperature rises. Glass is also a synthetic material: it is not mined as such but made by melting various raw materials together. Learning can also be seen as a process in which several elements are fused together and transformed into knowledge. I am not alone in thinking about liquids and learning. Emeritus Professor of Higher Education Ronald Barnett (2010, p. 24-33) uses the term liquid learning to describe learning that happens in multiple and simultaneous spaces. His use of the metaphor is connected to the concept of lifewide learning that entangles learning through various media simultaneously. To use liquid as a metaphor for learning feels appropriate as it is moving and transforming by nature: it spreads, spills, runs, fills gaps and holes and creates waves…

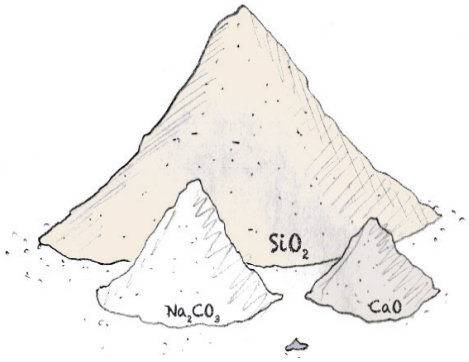
Metaphors as tools

When teaching, I have found metaphors to be useful instruments in explaining abstract subjects to students. Art students often seem to have prejudices towards natural sciences such as chemistry and physics because they are considered either difficult or irrelevant for art studies. As many of my courses' contents have involved the physics and chemistry of glass and thus been rather informative in nature, I have tried to make the content of learning more easily understandable by having a strong emphasis on practical work in laboratories and studios. I have also adopted a habit of talking using metaphors derived from a world more familiar to the students' everyday life. Experience has taught me that, for example, the viscoelastic nature of glass and pulling and compression tensions in the material have been better understood when I used a rubber band as a metaphor as it is an item certainly known to all. The illustrative nature of speaking seems to feel less frightening and makes it easier to get a hold on abstract issues. In my experience adults do not differ much from children in this matter.

Another case in which metaphors have proved useful is passing on tacit knowledge of a craft skill, for example, when teaching glass blowing. When I have to tell a student about the right timing for re-heating a glass piece it is no use talking about exact degrees Celsius as in the process of glass blowing there is no thermometer at hand. The student has to learn to interpret the right moment from the change of color, movement, sound and sense of used time to form an understanding of the material's behavior. Can you imagine the color of light apple juice? When the hot glass piece turns into that color and stops responding to the movements of your hand tools it is time to re-heat it. Metaphors are handy in teaching – as Lakoff and Johnson (1980) describe "… they allow us to make sense of phenomena in the world in human terms - terms that we can understand on the basis of our own motivations, goals, actions, and characteristics." (p. 34). Metaphors are tools to make thoughts more vivid and inspiring, but they can also structure perceptions and understanding.

Raw materials—the ingredients of teaching

Although the main focus of this article is the search for metaphorical parables in glass-making and learning, I feel that teaching has to be dealt with too. The goal of education—and teaching—is to facilitate learning. When comparing teaching and glass-making the most suitable metaphors are found in the glass batch—the correct mix of raw materials.



Picture 1: Raw materials of glass

Glass in its simplest form is made of three main raw materials: silica sand (SiO2), sodium carbonate (Na2CO3) and lime (CaO) (see Picture 1). Silica sand as the major ingredient (70%) forms the glass body, sodium (20%) helps silica to melt, and lime (10%) is a stabilizer that among other things prevents glass from dissolving in water. In addition, there are ingredients that are used to adjust certain physical or chemical properties of glass, for example metallic oxides to produce color. When making glass – optical glass especially – it is crucial to use clean raw materials with minimum iron content as it discolors glass even in miniscule amounts.

When thinking about teaching versus glass making, silica is a good metaphor for the subject that is being taught. Depending on the content and aim of a particular course, the body of it is the taught subject – no matter whether it is theoretical knowledge or practical skill. But how to get silica / the subject to melt and become approachable to the students? Let us add some sodium and thus use teaching methods to help. Sodium represents any chosen teaching method, such as laboratory and studio work, essays, reading, excursions or lectures. Methods vary according to the subject and the teachers' orientation. Experience tells me that hands-on-working in the studios is always happily welcomed by the art and design students. People who choose to study art or design are often practice-centered in their style of learning. In order to pass the entrance examinations, the students have to have experience in drawing, painting and/or sculpture, which means that the students tend to have a similar practice-emphasized style of learning when beginning their formal education.

After mixing subject and methods, lime is added to keep things together. In the glass-making process lime improves the chemical durability of the glass: it makes the glass resistant to water and most acids. Thanks to lime, windowpanes do not melt when rained upon. When compared to teaching, lime could represent the time and space in which a teacher works within a certain course. Time and space set the borderlines to many of the practical and substantial solutions that need to be framed. This includes, for example, the learning environment, the teacher's orientation, chosen context and point of view on the

subject, and the relation of the course to the curriculum. On the more practical side it includes timetables, teaching methods, and the methods of evaluation. All affect the event of teaching and thus also learning.

In addition to the three main raw materials of glass there are a number of other materials that are added to the batch. Colorants, opalizing, or decolorizing agents are added to adjust the type of color or the level of transparency of the glass. If the chemical formula of glass is analyzed thoroughly there are always minor amounts of oxides that are not added on purpose. Such oxides—for example the often unwanted iron oxide—are bound within the minerals of the main raw materials and cannot be fully avoided. A wise glassmaker takes them into account when designing the perfect batch for a good-quality glass.

The "other raw materials" represent the students as individuals with individual knowledge, motivation, and skills—all out of the teacher's control. I suppose most teachers have experience of teaching the same course for many years in a similar manner and getting different results and feedback depending on the students as a whole as well as on them as individuals attending the course. The students' personal skills and background knowledge affect learning on the personal level, but can also have an effect on other students' learning. They can also have an impact on teaching. In the best cases a teacher can use the skills and knowledge of one student to help others learn. An example of this is pairing a more advanced glassblower with a less skilled one, which in my experience tends to efficiently improve both the understanding of the glass-blowing process and the communication skills of both students. The more advanced student working on the blowing iron has to learn to communicate the working procedure to the assisting student in order to complete the blowing task successfully together. The assisting student learns the necessary steps in the blowing process and thus is eventually more prepared to start working with hot glass himself or herself. When verbalizing a working procedure and its goal one needs to see it from distance and inspect it analytically. Having to teach the process to others makes for efficient learning.

Glass melting is done in a furnace—a rather uncomfortable but useful metaphor for a class. At the beginning of an education program a selection of strangers form a class and they eventually merge into a group with its own dynamics. In order to get students to learn it is important that the group plays well together. In art schools, the groups are commonly small – often 8-15 students. The advantage of teaching small groups is that it makes it possible for the teacher to have a more personal connection with each student, but a downside can be that in a small group one dominant or quarrelsome student can disturb the work of the whole class – an experience certainly familiar to most teachers. In this article the quarrelsome dominant student gets the dishonor of being a metaphor for the iron oxide tinting the glass.

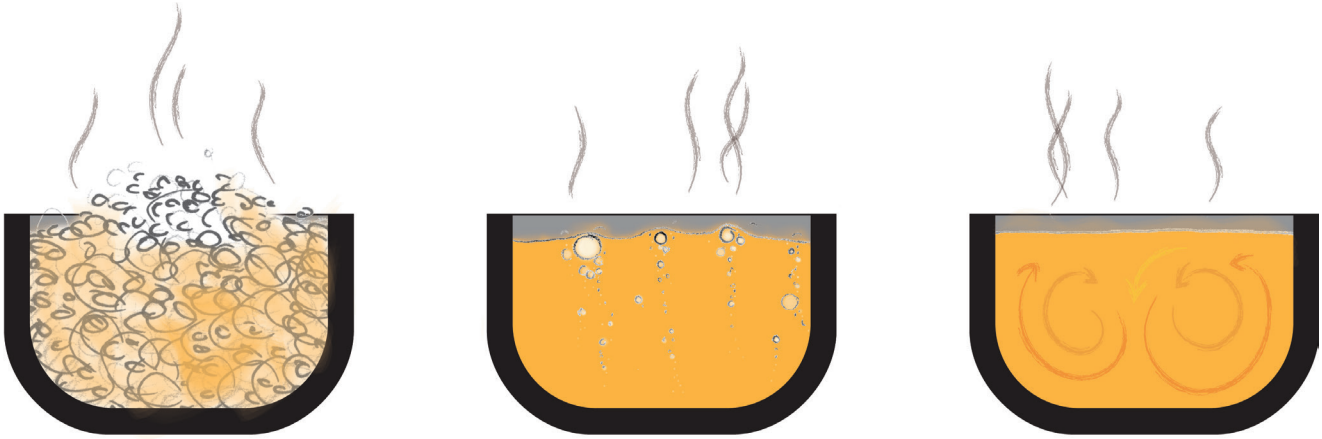
Primary melting – the learning begins

After the raw materials are thoroughly mixed and poured into the furnace the course is about to begin. *In the heat of the furnace (approx. 12000C) powdery raw materials begin to react with each other and*

melt into a foamy bubbly mass. Lots of gases (e.g. carbon dioxide, water vapor and nitrous oxides) are evaporated in the process (see Picture 2).

Primary melting is a great metaphor for the beginning of learning. Learning could be described as a process in which a person begins to see the subject as a new entity. The learner detects and registers patterns of relationships that characterize the area of the studied subject. It requires both motivation and interest, which hopefully already exist in the student's mind, but they can also arise in the course of learning after getting an initial grip of the subject and when the student begins to realize what the teacher is talking about. The learning process eventually fuses understanding and knowing into a person's awareness of the subject.

David A. Kolb, an American educational theorist, describes an educator's job as being not only to implant new ideas but also to dispose of or modify old ones. Resistance to new ideas often originates from their conflict with old beliefs that are inconsistent with them. He points out that the learning process will begin when the learner's old beliefs and theories are brought out, examined and tested and then the new and more refined ideas are integrated into the person's belief systems (Kolb 1984). Although Kolb's often referred to four-stage model on experiential learning has been later questioned (see e.g. Miettinen 2000), I agree with Kolb on the importance of testing one's old beliefs. To 'think outside the box' is a commonly used challenge for students of design. This is easier said than done. In order to do so, one needs to have the courage to inspect one's own beliefs and be able to question the customary solutions to the design problems at hand. One also needs to have an understanding of the wide range of possible approaches to the solution. How to support these processes is an inbuilt challenge of a teacher's work in the field of design. When it comes to melting as a metaphor, one could say that in a successful learning process uncertainty, misunderstandings and old beliefs slowly evaporate like gases from the glass melt.



Picture 2: The main steps of glass making process. From left to right: primary melting, refining and homogenization

The Refining process – peer-to-peer-learning

In the beginning of the refining process, the raw materials have melted and fused into a new material—glass. The glass is hardly useful yet as it reminds one more of foam than the clear, transparent substance we recognize as glass. A lot of gases are still evaporating and still need to evaporate. The refining process happens in two ways: physically and chemically. Physical refining means that big gas bubbles rise to the surface of the glass melt and escape (see Picture 2). In doing so, they pull smaller gas bubbles along and thus help them to escape too. The chemical refining process means that certain refining substances (e.g., sodium sulfate and antimony trioxide) are added to the glass batch to support the physical refining process. They can, for example, release big gas bubbles in the glass melt or dissolve the tiniest bubbles in the molten glass.

The refining process is a great metaphor for peer-to-peer-learning! When talking about art and design education especially, peer-to-peer learning is commonly supported in teaching practices—for example, small study groups, group projects, seminars and critiques, and making the students work hands-on and side by side in the same space are strongly rooted in the teaching traditions. The great strength of peer-to-peer learning in art and design studies is that it is versatile and even economical in a sense: a learner sees a much wider range of possible solutions to a given task than one would get by working alone. Seeing how fellow learners approach the task is also fruitful: one sees a variety of different sketching and working styles, means of problem-solving and ways to present one's ideas visually and verbally. Learning all the different approaches alone is either improbable or would take far longer—learning from each other is like physical refining! A teacher that understands the advantages of peer-to-peer learning can support the process intentionally—chemical refining in action. Voila!

Homogenization – practicing a skill

The gas bubbles are mostly gone now, and the last phase of the glass-making process is beginning. Compared to the two previous phases, homogenization is the most time-consuming and seemingly inactive phase. What could this slow stage of mere dwelling represent? However, there is more action in the furnace than meets the eye!

In the last phase of the glass melting process, the composition and temperature of the glass melt should become as homogenous as possible. During homogenization, the temperature in the furnace is raised, which speeds up the process of convection. In practice, this means that hot glass tends to rise upwards and cold glass sink downwards, which contributes to the movement of self-circulating currents (see Picture 2).

A metaphorical pair to the learning process is found in the light rotational movement happening in the hot glass melt—it is like practicing a skill through repetition! Imagine the silence in an atelier full of students deeply concentrated in croquis drawing.

Casting a lens – learners as molds

The glass is ready and it is time to use it to make a glass lens. There are several production methods to choose from, but let us choose casting, as it is very suitable for repetition and making lenses in quantities.

In casting, hot molten glass is poured into a mold (see Picture 3). The mold is filled; the glass settles in and shapes itself according to the shape of the mold. The glass hardens and cools down, and at the end of the process a pre-form of a lens is finished.

Picture 3: Casting a lens

It is tempting to use a mold as a metaphor for a learner. The teacher pours information into the heads of the students, and it finds a personal shape in each head. Every individual's perspective, temperament, worldview, other interests and skills, prejudices and beliefs, opinions etc. define a lot of how the information settles in and how knowledge and knowing takes shape.

Annealing – time and reflection

As a viscoelastic material with high thermal expansion, glass has to be annealed and cooled down slowly to remove internal stresses and to prevent new ones from building up. Internal stresses might cause the lens to crack or to weaken its optical properties. The annealing time varies depending on the exact composition and thickness of a glass piece – the logic being that a thick piece needs to cool down more slowly than a thin one.

Creativity and learning also need time. Like glass, information needs time to settle in to become knowing. One could describe the annealing phase in learning to be a process by which understanding and perception of the subject slowly mature. The knowledge of what has been taught begins to have a shape in the students' minds and hands. The potential and possible applications of the learnt subject begin to clarify. Annealing could also describe a reflective phase in the learning process. One has to linger on the subject and let it settle. One has to ponder and look back and think of what was taught and what it means. Learning takes time, and it even continues subconsciously which is a relief to notice, for instance, in cases of practicing a craft skill: in June one struggles with a new glass blowing technique, then gives up frustrated and heads off to one's summer holidays. In August, one returns to the studio and dares to try again – against expectations, the glass suddenly obeys!

Grinding and polishing – taking learning into practice

It is time to empty the lehr, which is the kiln in which the annealing took place, and continue working on the pre-formed lenses. The warm temperatures of the glass studio (the educational institution) are left behind and the work continues in the cold workshop (the "real world").

The molds and tools always leave marks on glass. For a good quality glass lens, it is important to have a perfectly even surface so that it refracts, reflects and transmits light optimally. The pre-form of a glass lens is mechanically ground and polished in order to remove possible marks on the surface and to shape it in such a way that it suits the desired purpose (see Picture 4).

Grinding and polishing represent taking the learning process out into the world. To really see if we have learned something and to deepen one's knowledge and widen one's understanding, we need to challenge it by using the knowledge in practice. Having to use a skill or knowledge puts it to the test – it forces us to activate in order to succeed in a given task. Practice reveals whether something has to be changed or if something works poorly. It shows us the things we need to inspect more thoroughly but also the things we master. Practice reveals the quality and depth of our knowledge. It also uncovers whether the aim of learning has been gaining knowledge about something or gaining knowledge of something. Scardamalia and Bereiter (2006) describe knowledge about as declarative or procedural knowledge and knowledge of as deep structural knowledge. Knowledge of includes knowledge that can be stated or demonstrated but also implicit or intuitive knowledge that has to be inferred. Knowledge of is activated when a need for it is encountered in action. (p. 10-11). One can always say that learning has succeeded if the students can, for example, repeat the facts from the slides shown on a lecture – easy to prove with a test. A different thing is to consider succeeding as an understanding of how these facts relate to other facts and how and for what purpose they can be applied.

Picture 4: Lens grinding

One frequently hears people saying that they have learned more of their profession not in school but in their first job or by working with "real life" projects during studies. I see this as a good example not of bad teaching but of the fact that learning is a continuous process that needs to be challenged in practice. Learning is not and should never be considered thoroughly finished. Practice grinds and polishes our knowing further and thus makes it more suitable for use. Certainly, lenses are ground and polished during university studies, but this also occurs after when lifewide learning is considered. Lifewide learning illustrates well the fact that learning is not solely in the hands of universities or other educational institutes but, as Barnett (2010, p. 24) puts it, lifewide learning is "… learning across an individual's lifeworld at any moment in time." Universities are no longer considered to be the sole gatekeepers of knowledge and learning. In art and design university education, the recognition of the advantages of lifewide learning have resulted in, for example, real-life projects, arranging student exhibitions outside the university premises and

internships in companies, which all prove to be useful in learning the practices of the profession. As Barnett (ibid.) says, universities have gradually released the students back into the world by accepting, for example, real-world projects and employment during vacations as spaces supporting and improving learning in addition to university teaching (p. 33).

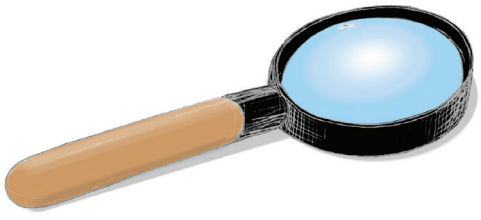
Lens in use – the beauty of knowing

Lenses are used, for example, in microscopes, telescopes, eyeglasses, cameras, fiber optics, and magnifiers (see Picture 5). The beauty of lenses lies in what they enable us to do: inspect single cells and reach deep into space to distant galaxies – meaning that we can extend our own eyesight. Knowing something extends our abilities to interact with the world around us. Devices with lenses operate within the focal length and focus area they are made to operate in. Knowing of one thing is good for knowing of one thing, but with a combination of different lenses a wider or a more specific operational field can be achieved. Cooperation and a multi-disciplinary approach can be efficient in many cases, or can help in reaching new solutions based on a diverse understanding of complex situations.

Glassmaking is a challenging process. Seeds (gas bubbles), cords and stones (e.g. non-fusible particles) are hard to eliminate completely from the glass melt. In lenses, they create trouble as they distract the transmission, reflection and refraction of light. Even the tiniest fault in a lens can lead to false information being gained through a telescope: "Oops, where did Jupiter go? It is supposed to be there between Mars and Saturn!"

What is learning gone wrong? One answer could be a lack of motivation or not taking full responsibility for one's own learning. It is a personal choice whether to take the easy way out and complete a course without putting much effort into learning. Of course, the teacher also has responsibility: what, where, why and how one is teaching are relevant questions. The teacher needs motivation to improve and master his or her own teaching too.

The world changes constantly, and the future is unknown. Knowing can age. Glass lenses can become scratched and clouded or even break. There is a need to adopt an attitude that embraces both life-long and lifewide learning and a willingness to keep updating the knowledge one has. Using a glass lens as a metaphor for learning is reassuring – lenses can always be re-ground and re-polished, and the glass can be recycled completely to make a new and perhaps a slightly different lens.



Picture 5: Glass lens in a magnifier

On metaphors and teaching

Metaphors that are grounded in our everyday experiences provide an essential means for comprehending abstract concepts. Teaching with metaphors is a way to illustrate information, but I also consider it a figurative language characteristic of me. As the teacher in the classroom, I am not a machine among other machines but a person interacting with other persons, thus my personality matters. Experience has taught me that if I am comfortable in the classroom, things usually go fine. Being comfortable requires, for example, not only that I have prepared the course well and that all necessary equipment functions, but also that I can talk the way I talk, and joke if I feel like it and if the situation allows it.

The challenge in using metaphors in teaching is to find parables from a world familiar to students. If I describe a certain movement one should do when working with hot glass on the blowing iron by describing how a robot's arm moves, one has to have an understanding of how a robot's arm actually moves: direct and tailored movement straight to target, no wobbling but precise and accurate. If a person has no idea of a robot, the metaphor rings no bell. Teaching foreign students brings other challenges for using metaphors, as one cannot be sure of the everyday experiences familiar to them, coming as they do from a different cultural and linguistic background. As Lakoff and Johnson (1980) write: "What is real for an individual as a member of a culture is a product both of his social reality and of the way in which that shapes his experience of the physical world" (p. 146).

A teacher always transfers values to students knowingly or otherwise. This is an issue with metaphors and language in general, too, as they convey cultural and personal values. For example, "bigger is better" and "less is more" are phrases that reveal a lot about the person's taste and preferences, values and even perspective on life. Lakoff and Johnson (1980, p. 23) note: "In general, which values are given priority is partly a matter of the subculture one lives in and partly a matter of personal values." There is a contradictory feature with values and art and design education: we as teachers want the students to develop a personal style, we emphasize the importance of originality and individuality, and we try to encourage them to think 'out of the box' and even be rebellious at times. The paradox is that in real life rebelliousness has to be done within the limits of unspoken and undetermined 'good taste' or of the common enough practices in the art and design field – 'be original but only as much as we can understand and approve of'.

When it comes to using metaphors in teaching art and design, they can be useful tools to help in investigating how we perceive the world and act upon those perceptions. The box in the 'thinking out of the box' metaphor represents restricted thinking and conventional practices and approaches to solutions which in this case are considered negative in a 'forget-everything-you've-been-told-and-taught-and-come-up-with-a-solution-never-seen-before' way. What would it mean if we rather thought of the box of being a toolbox providing us the means to grasp problems and help to solve them systematically in a 'take-what-you've-learned-and-told-and-use-it-to-make-a-solution-never-seen-before'' kind of way? Just a thought… a peek out of the box, as it were.

Conclusion

In the course of writing this article, I managed to re-polish my teacher's scratched eyeglasses. The search for metaphorical siblings in glass making and learning helped me to collect and verbalize some mental notes on my approach to teaching and to my ideas of a possible learning process. It is evident that a thorough and more detailed investigation could be made because the worlds of pedagogy and glass are wide and deep. As a rather practice-oriented person, I leave that to the possible future and head back to teaching and glass making. I have thought about an assignment I plan to test on my students. I will put their learning to a test by making them explain certain scientific concepts through metaphors they have to come up with by themselves. The hypothesis being that the search for metaphorical parables helps them to understand what the essences of the concepts are and thus helps them to take a step away from knowing about towards knowing of. Can the language of art be fruitful to learning something from another field?

References:

» Barnett, R. (2010). Life-wide education: a new and transformative concept for higher education? In N. Jackson & R. Law (eds.) *Enabling A More Complete Education. Encouraging, recognizing and valuing life-wide learning in Higher Education* (pp. 23-34). Conference proceedings. University of Surrey, Guildford, 13-14 April 2010. Surrey Centre for Excellence in Professional Training and Education

» Kolb, D. A. (1984). *Experiential Learning. Experience as The Source of Learning and Development.* Englewood Cliffs NJ: Prentice-Hall.

» Lakoff, G. & Johnson, M. (1980). *Metaphors We Live By.* Chicago. The University of Chicago Press Ltd.

» Miettinen, R. (2000) The concept of experiential learning and John Dewey's theory of reflective thought and action. *International Journal of Lifelong Education*, 19 (1), 54-72.

» Scardamalia, M. & Bereiter, C. (2006). Knowledge building: Theory, Pedagogy, and Technology. In K. Sawyer (ed.) *Cambridge Handbook of the Learning Sciences* (pp. 97-118). New York: Cambridge University Press