Introducing bamboo in the education of the building engineer. So cool!

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Abstract

If we believe there is a crisis regarding global warming, pollution, and social injustice, and if we want to act on it, we need to open our minds, change our attitudes, and start preparing with our young students. Together we need to develop a way of thinking that implies the use of a new set of values that differs from today's mind-set and values that caused this crisis in the first place.

With this in mind we proposed a group of students and professors to consider building structures with an alternative material: bamboo, a material with which neither students nor professors had any experience in. During the course of this exercise the conceived structures developed from simple to complex designs, from required forms to free ones designed by the students, from small 1:100 scaled models to bigger 1:20 ones.

Not theory but the practice itself generated a tremendous amount of enthusiasm within the group of students and within the group of professors. Knowledge of the stability of skeletal structures was gained in a playful way; theoretical thinking-errors were immediately tested by the practical execution of the newly developed model. The existence of alternative construction materials, in this case bamboo, the feel for the material and its numerous possibilities for construction purposes were being revealed! For the involved students and professors the practical aspects of this exercise created more awareness and knowledge on the topic than any theoretical lecture could.

In awe.

When architecture students are confronted with great architecture they are in awe. They aspire to become architects because they want to create marvellous buildings that match and surpass the designs they have seen in and outside the classroom. On the Internet they find bridges that curl up like an insect to give free passage to boats, or a pavilion that resembles a futuristic porcupine, or a power plant in the shape of a magic mountain. [1] If they are not only interested in new dazzling shapes but also in the social importance of buildings, they can witness the marvel of a mobile hospital, or even an eatable clinic. [2] They can dream away wondering about the feasibility of a 6,000 kilometres long wall crossing the African continent, made of sand and bacteria, where people can grow crops, live, and at the same time stop the desert of expanding by 2 m each day. [3] All this inflames the imagination of the architects to be.

Is Bamboo also such a strong seducer to the minds of our youngsters? The quality of bamboo as a building material is beyond discussion. However, it is not widely accepted in building practises, or the education of the building engineer today.

In March 2012, eight students of the Avans University had their first encounter with life in a slum in Kenya. They visited Kibera, one of the largest slums of Nairobi, talked to the people, and read about their way of life. After analysing all the findings they came up with a cheap building material to improve the living conditions in Kibera: Bamboo the miracle plant! The practical applications of this material are as diverse as they are numerous: you can eat it, weave clothes out of it, purify contaminated soil with it and take away carbon dioxide out of the air. You can use it as a fuel to cook your meals and you can use it to construct a house solid enough that it won't wash away with the next heavy rainfall.

For a lot of reasons the Kiberians refused the material. One of them was the unappealing thought of living in a house made out of an inferior material. The people whom they worked for as gardeners, maids or drivers didn't live in houses made out of bamboo, their houses were made out of poured concrete, concrete blocks, bricks and steel. These building materials were the standard, and had a significant social connotation for the slum dwellers. Their next step on the social ladder was in the form of a house made out of concrete, bricks and steel, like those of their employers, not one made out of bamboo.

Bamboo is a non-conventional building material and as such rejected as part of the solution towards better living conditions. Bamboo does not fit in the picture of a better future. So, if even a Kiberian won't accept this miracle of nature as the next standard of building, why would (for instance) a young Dutch couple choose to invest in this material as being the main construction material of their expensive home? What about ten or twenty years from now? Will a house made out of bamboo keep its value on the real estate market?

It's a gamble only a few are willing to take. This gamble perception is caused by our way of thinking, by our education.

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[1] Headerwick, T. (2011 03). *Thomas Headerwick.* Retrieved 02 01, 2013 from www.ted.com: http://www.ted.com/talks/thomas_heatherwick.html

[2] Sinclair, C. (2006 02). *Cameron Sinclair on open source architecture.* Retrieved 02 01, 2013 from www.ted.com: http://www.ted.com/talks/cameron_sinclair_on_open_source_architecture.html

[3] Larsson, M. (2009 07). *Magnus Larssen: Turning dunes into architectuture.* Retrieved 02 01, 2013 from www.ted.com: http://www.ted.com/talks/magnus_larsson_turning_dunes_into_architecture.html

Education.

From a manufacturing model towards an agricultural model.

How to create a massive audience for bamboo, or more in general for non-conventional building materials and techniques?

According to Ken Robinson we are not facing one global crisis, but two. The first, being the climate change due to the activities of the human race, the second is clinging to an obsolete education system. [4] This system is characterised as a manufacturing model where linearity, conformity, and bashing people are the keywords all through the curriculum of the learning process. This system has little or no room for tailor made education. Robinson is proposing a new system of education: a system as an organic model, where variety is permitted, where people have the opportunity to develop the personal potential to the fullest. It is somewhat like agriculture. Schools should encourage students to become the people who they really are, should build upon the passion of every student, and should create the conditions in which exactly this can happen. [5] An agricultural model at the basis of our education system is very much needed to solve the first global crisis. We need minds that can think differently than the minds that created the problem in the first place. We have to be able to think anew, to excel. How can we encourage (young) people to learn, to excel?

The brain of the student.

What would an agricultural model look like? How to see students as individuals and not as a group of full-grown young adults within the world of education?

In their book 'Puberbrein binnenstebuiten' [6] (The adolescent brain inside out) Nelis and Van Sark are asking themselves how a brain of a young adult develops. How this results into the specific and personal skills and behaviour pattern of students. As the brain is only fully grown at the age of twenty-five, the need for boundaries to give to students of this age is bigger than we imagine. A clear framework of rules is vital to create conditions in which the students feel save and encouraged to explore new grounds and possibilities, to develop their personalities and to pursue their passions. Nelis and Van Sark go on by defining the environment for a quick and effective learning process. Students should be treated as equals, who have a say in what, where and how. A professor is there to challenge and to support, is part of the world of the students and is letting them know he or she thinks highly of them.

On page 83 there is a description of "The quality of the teacher of the year" [7] (easily to be extended to the quality of a university professor):

The teacher of the year is stern but just and is passionate about his or her field of expertise. He or she is not on automatic pilot, is not a teaching machine, nor a fanatic, nor the 'best friend' type. The teacher is a friendly jet strict example figure, is constantly developing his / her professional skills. [8]

Understanding the working of the adolescent brain, we can focus on how we can improve our educational system in order to maximize the development of the potential of the adolescent. In their

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[4] Robinson, K. (2006 06). *Ken Robinson: Schools kills creativity*. (ted, Producer) Retrieved 02 03, 2013 from www.ted.com: http://www.ted.com/talks/ken_robinson_says_schools_kill_creativity.html

[5] Robinson, K. (2010 02). *Sir Ken Robinson: Bring on the learning revolution*. (ted, Producer) Retrieved 01 31, 2013 from www.ted.com: http://www.ted.com/talks/sir_ken_robinson_bring_on_the_revolution.html

[6] Nelis, H., & van Sark, Y. (2012). *puberbrein binnenstebuiten.* utrecht/antwerpen: Kosmos Uitgevers.

[7] Ibid.

[8] Ibid.

second book 'Over de top – Haal het allerbeste uit jongeren' [9] (Over the top – Get the very best from adolescents) Nelis and Van Sark emphasize the fact that characteristics of an individual are for a mere 50% inherited, sits within our DNA, the other 50% must be gained by nurture. How should this nurturing look like? What to do to communicate with the adolescent brain, or better, with the adolescent? In order to make students excel, bring out the best in them, an education system should focus on training, exemplary behaviour and verbal encouragements.

Nelis and Van Sark list ten pointers for school management and ten for the teaching staff. [10] The management of any school should make up a to do list: be aware this change in the education system is a culture shock - invest in your teachers / professors – build a strategy around excellence – make choices – look beyond your field – be thoughtful of motivating students and staff – create a bond between students and school – work together – involve the parents.

The quality of the teaching staff is improved when teachers - are conscious of their important influence on adolescents – are inspiring – stimulate self-regulation – explain the importance of lots of training – adapt the curriculum in order to challenge when excellence is spotted – stimulate a growth mind-set – develop extra curriculum parts so excellence of students is acknowledged by means of an extra certificate – are alert of social loafing and free-riding in group assignments – know the dreams and interests of the students – are proud of the students and show this to them.

Reading the above, one could wonder about the type of courses, which can do all of this. I find myself looking at lectures, workshops, and assignments. And I can't help wondering how a human being is learning in a natural way. How creativity is provoked. This takes us to the next two sections.

Playing = learning?

In their paper "Learning to play, playing to learn. A case study of a ludic learning space" [11] Kolb and Kolb are referring to several academics who explore the theme of *play* within de realm of learning. While according to Kolb and Kolb J. Huizinga [12] is contending "that from the very beginning, cultures evolved in forms of play"; [they make a list of] "scholarly inquiry across diverse fields of social science with a substantial accumulation of theoretical and empirical evidence about its significance in the process of individual expression and adaptation"

Singer et al. are emphasizing the importance of '*play in human cognitive and social-emotional growth*'. Furthermore they state: "in reality, play has been devalued and continues to be squeezed out of our formal educational institutions under the misguided view that learning is reserved to the classrooms and play should be confined to the playgrounds without consideration of the detrimental effect that such a distorted separation of play and learning might have on human growth and development"

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[9] Nelis, H., & van Sark, Y. (2012). *over de top - Haal het allerbeste uit jongeren.* Utrecht/Antwerpen: Kosmos Uitgevers.
[10] Ibid.
[11] Kolb, A. Y., & Kolb, D. A. (2009). *Learning to play, playing to learn A case study of a ludic learning space.* Weatherhead School of Management, Case Western Reserve University; Cleveland, Ohio, USA. Cleveland, Ohio: Case Western Reserve University. Further referred to as: Kolb & Kolb, *Learning to play.*
[12] Huizinga, J. (1974). *HOMO LUDENS.* Groningen, the Netherlands: H.D. Tjeenk Willink.
See also:
Huizinga, J. (1949). *homo_ludens_johan_huizinga_routledge_1949.pdf.* Retrieved 02 09, 2013 from www.art.yale.edu: http://art.yale.edu/file_columns/0000/1474/homo_ludens_johan_huizinga_routledge_1949_.pdf And: Huizinga, J. (2012, 04 22). *Homo-Ludens--Study-of-the-Play-Element-in-Culture--International-Library-Society--by-Johan-Huizinga_161795.* Retrieved 02 08, 2013 from www.ebook3000.com: http://www.ebook3000.com/Homo-Ludens--Study-of-the-Play-Element-in-Culture--International-Library-of-Society--by-Johan-Huizinga_161795.html

This is something Ken Robinson also is acknowledging very strongly.

Kolb and Kolb advocate "the concept of ludic learning space, wherein learners achieve deep learning through the integration of intellectual, physical, moral, and spiritual values (Kolb, 1984) in a free and safe space that provides the opportunity for individuals to play with their potentials and ultimately commit themselves to learn, develop, and grow" [and suggest] "that a ludic learning space opens up possibilities for individuals to become intrinsically motivated to define for themselves what to learn, how to deal with change, and ultimately reinventing themselves within the safety of the space."

A free and safe space, which was also important to Nelis and Van Sark to get the most out of the adolescent brain.

To create a ludic space [13] one has to pay attention to a few things.
Play is free; it is stepping out of "real" life, and is bound in space and time. It begins and ends within a limited time; therefore it demands order. Lacking this order or a slight deviation of this order will result in the collapsing of the play space.
A ludic space is created by the nature and the structure of the game and by the conducts of the players. In doing so free play enables the creation of a self-organizing system wherein the players are responsible for ordering and shaping the goal of the game and the experimental learning cycle – experience, reflecting, thinking and acting – is implemented.

Kolb and Kolb conclude in describing the three most important characteristics of working with the ludic space:
It encourages learners to take charge of their own learning based on their own standards of excellence. They achieve authentic and higher order learning by creating their own rules and conduct.
Process and outcome are equally valued. A truly educative experience sees no difference between utility and fun.
The experimental learning cycle is guaranteed by allowing players to come back to the familiar experience with a fresh perspective. From moment to moment, step-by-step, the individual's experience matures and deepens through the recursive nature of the play activity.

The art of creative thinking.

In his paper *Creative Action Methodology - What is it all about? What does it mean in practice?* [14] And his thesis "Onderwijs, onderzoek en de kunst van het creatieve denken." (Education, research, and the art of creative thinking.) [15] Paul Delnooz is explaining what to do when a better result in the education of a university student - in the field of applied science - is wanted.

According to Delnooz a learning process consists out of four steps:
"Knowing": In solving a practical problem students needs to know all the stakeholders and their interests; the available statistical material; the existing theories; the actions already taken towards solving the practical problem, and why these actions were successful or not.
"Activation of the brain": To produce new insights, and potential solutions to a problem it is necessary to create a new way of looking to the problem by combinatorial and lateral thinking. This includes a-logical and unorthodox thinking methods, as well as a methodical approach based on "doubt" and "reflection."

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13 Kolb & Kolb, *Learning to play*
14 Delnooz, P. (2006). *Creative Action Methodology.* NHTV Breda University of Applied Science. Breda, the Netherlands: NHTV. Delnooz, P. (2006). *Creative Action Methodology.* NHTV Breda University of Applied Science. Breda, the Netherlands: NHTV.
15 Delnooz, P. V. (2008). *ONDERWIJS, ONDERZOEK EN DE KUNST VAN HET CREATIEVE DENKEN.* Tilburg, Brabant, Nederland: SCIENCE GUIDE.

“Reflection”: It is important to be able to build up a solid argumentation to indicate the validity of the solution. Scientific and non-scientific knowledge are examined. Solutions are not always the result of logical reasoning.
“Implementation”: In order to expand the knowledge and research capabilities of the student step by step, students are asked to perform a follow-up action - it involves a cycle in which the student is encouraged towards creative, analytical and reflective thinking, with the aim of shifting the zone of proximal development a little further every time. The testing of the solution plays a key role in the overall learning process. It is also called the double loop.

In this process it is absolutely vital teachers have a high degree of content expertise, stimulate students constantly towards reflection and result, use a methodological approach based upon “doubt” and “reflection”, aren’t using a directive teaching style. Rather than presenting facts and truths to students mainly in the form of recipes, the teachers are forcing the students to question all knowledge and reflect on that.

In this process students will be in the beginning unsecure. They slowly grow accustom to the idea that there is more than one answer to a problem. Students experience a culture shock; they discover they can’t connect anymore with a familiar education system, which in the end makes them able to put things into perspective. They experience an innovation shock; there are no certainties because everything is questioned, they learn to construct arguments and think for themselves.

What to remember?

Robinson, Nelis and Van Sark, Kolb and Kolb, and Delnooz all of them have, in relationship to the course “Building with Bamboo”, something to consider:
Robinson: Build your education system on the basis of the agricultural model where there is room for the passion of every student, room for a new way of thinking.
Nelis and Van Sark: The brain of your student isn’t fully-grown yet. The behaviour of your student is that of an adolescent. Therefore you have to give your students order in which they can feel save to explore without being afraid of humiliation when they are making a mistake. There must be an emphasis on training. Teachers should connect with their students.
Kolb and Kolb: The ludic space enables learners to take charge of their own learning based on their own standards of excellence. They achieve authentic and higher order learning by creating their own rules and conduct. A truly educative experience sees no difference between utility and fun. From moment to moment, step-by-step, the individual’s experience matures and deepens through the recursive nature of the play activity.
Delnooz: There is no objectivity – knowledge, the view on reality is a constructed view (cube versus a bunch of lines) the view on reality is context affiliated (12, 13, 14 vs. A, B, C). [16] Solutions are not always the result of logic. An open mind is created by lateral, and combinatory thinking; by scientifically, and non-scientifically approaches; by developing multiple visions (enlighten) – presenting multiple actions (engineering) – experimenting – testing. The education should be shifting the zone of proximal development of a student a little further every time.

Let’s see what we can do with these thoughts to evaluate our course.

Constructing with bamboo - a case study.

A 10-week design and building course.

Part of the minor Architecture at the AB&I (Academy of Building and Infra structures). Designed for students of the senior year of a four year curriculum, bachelor level.

[16] Ibid.

Planning and executing the course.

Assignment:

Design and build a skeleton structure made out of 250 bamboo poles, each 4 m long and 2 cm thick, within a group of 4 to 5 students. Pay special attention to the materials that secure the construction nodes, which should be, like the bamboo, preferably made out of a sustainable material. The forming of the groups is left to the students.

Study load:

3ec (1ec = 28 hours of study) per student over a period of ten weeks. This adds to an average of 8,4 hours a week per student.

Study program:

The first seven weeks the 6 groups of four students each receive weekly assignments, which they have to complete and present the week following the week of the publication of the assignment. Their work is evaluated each on a weekly basis. Handing out the assignment of the coming week and evaluating the assignment of the past week takes 15 minutes. In week eight the students prepare to built their designs, which they will execute in week nine resulting in the final construction. In week ten the projects are taken down and the materials are returned.

Study goals:

Gather knowledge in working with skeleton constructions and construction nodes.
Learn how to design and make an innovative skeleton construction.
Be acquainted with bamboo, a non-conventional building material.
Be encouraged to work with sustainable building materials.
Practices experimental research and work methods.
Learn how to work within an interdisciplinary group.

Criteria used to judge the work, results, and process:

Is the construction stable? Are the nodes stable?
Are the characteristics of the material fully exploited? Is the material used in an effective way?
Is the construction complex?
Is the construction challenging in size? (Length, height, width)
Is the design of the construction elegant, well executed, finished?
Is the design of the construction original?
Is the design of the construction experimental?
Is there a peer-assessment?

Teacher's expertise:

The two teachers who gave this course are both architects by profession.
As it was the first time to introduce constructions with bamboo in the curriculum, students could not capitalize on previous experiences or specific expertise from the teachers. To compensate this lack of knowledge guest lectures were organized with expertise on bamboo characteristics and on making construction nodes with sustainable materials.
The teachers got well acquainted with the students, as there has been a lot of contact with the students throughout design projects, lectures, and workshops during a period of two years prior to the senior year.

Course type:

The course was workshop focused with theoretical support in the form of generic theory sessions, expertise guest lectures on building with bamboo and nodes.

Course progress:

Week 1:

Assignment: Build one of the five Platonic solids: Tetrahedron – Hexahedron – Octahedron - Dodecahedron – Icosahedrons. How many sticks are necessary to produce a stable construction?
Building elements provided by the university: Fifty bamboo sticks of 80cm long and 3mm thick and a box of rubber bands.
Additional information: Websites about Plato solids [17]
Observation: It is discovered that two of the solids are too easy to make: tetrahedron and hexahedron. Therefore the assignment is restricted to the other three solids: octahedron, dodecahedron, and icosahedrons.
Week 2:
Presentation on the constructed Plato Solids: Some solids are stable by themselves (tetrahedron, octahedron, icosahedrons) – some are not (hexahedron, dodecahedron) and need additional sticks of bamboo to stabilize the solids. Each team of students creates a different kind of stabilizing system. These systems are compared in regard to how many additional sticks were used.
Observation: after a brief time of wondering how to go about, building the solids goes extremely fast! Most of the groups didn't build one but two Plato Solids. *Enthusiasm is big.*
Assignment: Build an Archimedean solid.
Building element provided by the university: one hundred bamboo sticks and rubber bands.
Additional information: Websites about Archimedean solids are provided. [18]
Guest lecture: The amazing strength of bamboo, by Johan Gielis. [19]
Week 3:
Presentation on the constructed Archimedean solids: The solids are not stable. Each team of students creates a different kind of stabilizing system. These systems are compared in regard to how many additional sticks were used.
Observation: Most of the groups chose a complex Archimedean solid, which led to shortages of bamboo sticks. The running out of bamboo sticks was however countered by the students adaptively. They made half a solid and placed it on a reflecting floor!
Assignment: Build a Buckminster Fuller or geo dome.
Building elements provided by the university: 250 bamboo sticks and rubber bands per group. Start thinking of designing the final construction based on the superflows [20] encountered on the website of Genicap.
Additional information: Websites about Buckminster Fuller [21] and geo domes and the Genicap [22] structures are provided.
Workshop: Learning how to make a knob to connect several bamboo poles together with a sustainable material, by Georges Cuvillier. [23]
Week 4:
Presentation on the constructed geo domes: Six different types of geo domes were constructed which all were stable. *Good for you Buckminster Fuller!*
Observation: One of the groups tried to build a geo dome twice the size of the other. Surely the element of competition was finding its way into the game. The group choose to build out in the open. The dimensions of the ribs were twice the size of the bamboo sticks. The construction took a

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[17] Short, I. (1997). *Paper Folding - Models of the Platonic Solids : nrich.maths.org*. (U. o. Cambridge, Producer) Retrieved 08 17, 2012 from nrich.maths.org: http://nrich.maths.org/5480/index
[18] *Paper Model of a Truncated Icosahedron (footbal)*. (n.d.). Retrieved 08 17, 2012 from www.korthalsaltes.com: http://www.korthalsaltes.com/model.php?name_en=truncated%20icosahedron
[19] *Johan Gielis*. (2004, 11 18). (Radboud University Nijmegen) Retrieved 08 17, 2012 from www.pg.science.ru.nl: http://www.pg.science.ru.nl/en/johangielis.html
[20] *Demonstration of the Superformula app on Vimeo*. (n.d.). Retrieved 08 17, 2012 from vimeo.com: http://vimeo.com/20774653
[21] Wikiquote. (n.d.). *Buckminster Fuller - Wikiquote*. Retrieved 08 17, 2012 from en.wikiquote.org: http://en.wikiquote.org/wiki/Buckminster_Fuller
[22] Genicap. (n.d.). *Genicap*. Retrieved 08 17, 2012 from www.genicap.com: http://www.genicap.com/Site/
[23] Cuvillier, G. (n.d.). *Georges Cuvillier - Portfolio*. Retrieved 08 17, 2012 from www.georgescuvillier.be: http://www.georgescuvillier.be/

lot of time to build and eventually collapsed due to rain, overestimating the strength of the prolonged bamboo sticks. Despair caused the abandoning of the structure.
Assignment: Design and build a tower or a bridge with 250 bamboo sticks.
Building element provided by the university: 250 bamboo sticks and rubber bands per group.
Week 5:
Presentation on the constructed towers or bridges: Very skinny bamboo sticks can construct very high stable tower constructions. Constructions went as high as 15 m!
Observation: The group who had a disaster the week before had the highest tower now. The girls strike back! Other students of the university are starting to ask if this course will be given next year as well.
Assignment: Design and build a Superflow with only 250 bamboo sticks based on the designs you find on the website of Genicap. [24]
Building element provided by the university: 250 bamboo sticks and rubber bands per group.
Week 6:
Presentation on the constructed hyperboloids, Möbius rings, superflows, arches.
Observation: Parallel to the bamboo course there was another design course: the Symbolique Space. Students of the third year are asked to design a space for the Ritman library [25] in the vicinity of a Palladian villa. Curiously enough there were a lot of dome construction in the designs of these students.
Assignment: Design your final proposal for a structure out of bamboo on a scale 1/5 with 250 bamboo sticks.
Building element provided by the university: 250 bamboo sticks and rubber bands per group.
Week 7:
Presentation on 8 proposals on a scale 1/100 – 4 of them are chosen to be constructed on a bigger scale 1/20 with bamboo poles 4 m long and 20 mm thick.
Observation: Results are miscellaneous: some are carefully thought through, some are careless, some are limited in ambition, some are grand, some are unstable, some of the models are using a wrong scale. We have to take in consideration the safety of the students while they are building the structures. Four structures are chosen. They are to be constructed outside on the land next to the University building. Students had a 50% vote, teachers had a 50% vote.
Assignment: Build your own chosen design with bamboo poles of 4 m long and 2 mm thick in week 9. Pay attention to the execution of the work, the firmness of the nodes, the safety, the stability of the construction during the work. No tools besides bamboo and rope are permitted. No ladders, no crane, or any other building material is allowed.
Building element provided by the university: 250 straight bamboo poles of 4m long and 20mm thick per group of students.
Week 9:
Presentation on the constructed four structures made out of bamboo and other materials.
Observation: Different kinds of structures were planned, built, and constructed.
The “Umbrella” Very design like – well taken care off – nodes were executed with extreme care – stabilization of the structure well studied.
The “Superflow #1” It was the quickest to construct; the nodes were made out of tapes and tapes and tapes; stable but not executed with care; it was the abundance of tape that stabilized the construction; not the engineering or designing of the nodes.
The “Superflow #2” Failure in erecting the biggest structure led to awkward disagreements in the group, a clash of egos was revealed, coffee created a momentum to get the students working again. The next morning the group succeeded, with slight modifications to the structure, to build the structure to be presented, a half an hour before closing time.
The “Coral” The group had learned not to overestimate time, strength, and endurance and found them at the other end of the scope. The structure was low in ambition, well executed, and carefully designed nodes made out of sustainable materials.

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[24] Genicap. (n.d.). *Genicap*. Retrieved 08 17, 2012 from www.genicap.com: http://www.genicap.com/Site/
[25] The Ritman Library. (n.d.). *Bibliotheca Philosophica Hermetica*. Retrieved 08 17, 2012 from www.ritmanlibrary.nl: http://www.ritmanlibrary.nl/

Assignment: In week 10 constructions are taken down, materials are returned.
Week 10:
Presenting: An empty piece of land next to the university building nicely cleaned up.
Observation: One of the six structures was still standing; debris everywhere, a lack of discipline to clean up the site was imminent.

Evaluating the course.

Were the study goals reached?

Going over the goals formulated in the course manual we can make some observations in relations to these goals:
Gather knowledge in working with skeleton constructions and construction nodes. No rapports were asked; no examination took place in order to check the improved knowledge of the individual student.
Learn how to design and make an innovative skeleton construction. Designs were there, some were innovative to a high degree, others not so. Despite the workshop given by Georges Cuvillier, not one group used the node techniques Georges had shown them, resulting in a varied degree of excellence concerning the making of the nodes.
Be acquainted with bamboo, a non-conventional building material. Bamboo was present the hole 10 weeks; students learned how to build with it, while experiencing failure and success.
Be encouraged to work with sustainable building materials. Some group incorporated the thought of sustainability into the designing of the nodes, others forgot about it.
Practices experimental research and work methods. All students were very enthusiastic about the course. The outcome of the research stayed however undocumented and therefore obscure. During the course, students were amazed by the strength and lightness of the constructions in bamboo.
Learn how to work within an interdisciplinary group. Going from eight groups to four proved to be fortunate for six of the groups, two groups had to overcome differences of opinion regarding how to construct the chosen design. Four out of eight groups had the discipline to clean up afterwards; four were reluctant to clean up the site. Four groups delivered peer-assessment forms in time; four groups delivered them a week overdue.

Judging by the criteria formulated, was it a success?

Is the construction stable? Are the nodes stable? All of the designed met the stability criteria.
Are the characteristics of the material fully exploited? Is the material used in an effective way? These questions are difficult to answer because teachers were lacking expertise in building with bamboo. They were learning at the same time as the students.
Is the construction complex? The superflows complexity was created by their cantilever parts, the complexity of the umbrella was created by resolving the rotation of the umbrella and the stabilizing by linking the four umbrellas to each other.
Is the construction challenging in sheer size? (Length, height, width) The two superflows were the biggest. The umbrella and the coral were modest.
Is the design of the construction elegant, well executed, finished with care? One design stood out: the umbrella design, followed by the coral. The superflows were too big to be elegant and not well executed; especially the nodes of the construction were atrocious.
Is the design of the construction original? All the designs were original; none of them were copycats of existing structures.
Is the design of the construction experimental? The course was experimental; most of the designs of the constructions were playing it safe, learning from earlier mistakes, only the umbrella had a high degree of experimenting with the stability of the structure.
Is there a peer-assessment? Eventually all peer-assessment forms were delivered. It is obvious that filling in a form isn't as much fun as building a bamboo construction.

Was it Playing? Was it Creative?

There was the passion of the students.

There was order in which the students could feel safe to explore. The course was limited in time and had clear assignments. The study load was neither high nor low.
There was training guaranteed by the assignments week after week with a rising complexity.
There were teachers connecting with students, students connecting with students.
There was a bond with the University. Students were building their models in the hallways of the university building.
There were students who took charge of their own learning based on their own standards of excellence.
There was moment to moment, step by step, the maturing and deepening of the individual's experience through the recursive nature of the play activity.
There were solutions, which didn't come logically. Creativity emerged from a shortage of bamboo sticks.
There were minds were opened by feeding the students Plato, Archimedes, Buckminster Fuller, Genicap. Lateral, combinatory thinking, scientifically, and non-scientifically approaches, developed multiple visions (enlightment) – presenting multiple actions (engineering) were experienced almost subconsciously.
There was experimenting and testing. None of the students and teachers was familiar with working with bamboo.
And there was the zone of proximal development of the students that advanced every week during the course.

Conclusion.

"Building with Bamboo" certainly made the students and teachers enthusiastic. It was an event nobody in the school could ignore. I don't know if all the students have learned and deepened their knowledge of constructing things equally profound. Is there a type of course, a teaching method that can guarantee this? Anyway it wasn't the main purpose of the course. The main aim of this course was to create an awareness of the possibility there are some unexplored territories in the field of construction, building that could be useful in preparing future generations to cope with the global and local problems in this rapidly changing world. The main aim was to let students experience that experimenting is fun, is creative, and is worthwhile doing. It is good for building their confidence as well as their knowledge.
Next year we could ask rapports in which students make clear they learned something about a stable construction. We could organise a written test. We could increase the complexity of the assignments. We could increase the attention to the nodes by every group. We could improve lateral thinking by looking to other fields beside building or architecture where skeleton constructions are investigated.
No matter how we will improve it, it will always be by keeping the passion of the students as high as possible, and now, more than ever I am convinced playing with non conventional building materials and techniques is a path we should thread upon.

Epilogue.

Mixing, gaming and fun.

Mixing.

Serendipity, the happy accident, the moment of genius, is so unpredictable. [26] But isn't there a way of creating conditions to maximize the chance of getting more serendipity moments? Every method, used in science, used in education, is valuable. Combining things is leading us to new insights.

Based upon years of experience in teaching architecture students, I took the liberty of mixing some key notes of the Avans University (Innovation, Sustainability, Social Relevancy) with a form of learning which I remembered to be very pleasant, and which had a great impact on me as a young student: learning by doing.

The minor Architecture at the Academy of Building and Infrastructures has, over two periods of ten weeks, a big diversity of addressing the students. There are seven courses, one with a study load of 12ec, 6 with a study load of 3ec each, among them this course: "Constructing with Bamboo." In each course there is a different approach to develop the interest of the students in their favourite field: architecture. There is no endless repetition of the same type of course over and over again. Students find themselves always running out of time, but they have the feeling of learning and evolving very rapidly. Analysing and designing, reflecting and synthesizing are attitudes the minor is making sure students are coming in contact with.

If we would change something about "Constructing with Bamboo," we have to be careful not to lose the equilibrium with the other components of the minor. A right mix of different types of courses is necessary to prevent feelings of boredom and created stimuli to keep the students going.

In designing courses for the education of a building engineer I have learned to search for balance and looking for the right mix in the curriculum. Students come in so enthusiastically. We cannot afford to let it go to waste.

In the aftermath of the course my colleague Michiel Smits and I were asked to present our course at the University Day at Deventer November 2012. Professors in building engineering were given the assignment to build a stable solid of Plato or/and Archimedes within a timeframe of 30 minutes. Professors were actually experiencing again what it meant to be a student, what it was to construct. The groups of professors did very nicely, although there were some not so passionate. Preparing for this day I encountered a few interesting websites regarding the use of bamboo.

In the aftermath of the course and the University Professor's day at Deventer, I was asked to lead a new graduation studio: the "Red and Green" studio (Bachelor level). 'Red' standing for 'Technical' and 'Green' for 'Sustainable'.
Preparing for this new studio I scrolled over the Internet looking for information that could thrill the students, make them sit on the edge of their chair, make them want to play. Some 'new' topics caught my attention.
'*Efficiency,*' a concept already advocated by Buckminster fuller [27, 28, 29] in the late 1920's uttering the words: "Do more with less."

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[26] Wikipedia. (n.d.). *Role of chance in scientific discoveries*. Retrieved 01 28, 2013 from en.wikipedia.org: http://en.wikipedia.org/wiki/Role_of_chance_in_scientific_discoveries
[27] evemag13. (2009, 02 24). *watch?v=uYv1fM4-hpM*. Retrieved 12 21, 2012 from www.youtube.com: http://www.youtube.com/watch?v=uYv1fM4-hpM 6:00
[28] Snyder, R. (2009, 03 15). *The Green World of Buckminster Fuller - Preview*. (mmczech76, Producer) Retrieved 12 21, 2012 from www.youtube.com: http://www.youtube.com/watch?v=DJ06EE_cnyc 2:39

'*Bio mimicry,*' in the late 1930's used by Frank Lloyd Wright when working on the construction design of the Johnson Wax building in Racine. The studying of the strength of two cacti, the Saguaro or barrel cactus and Staghorn Cholla, standing tall in the desert, led to stronger and slender columns at the Johnson Wax headquarters in Racine Illinois.[30] More recent, Michael Pawlyn is designing structures in the middle of the African deserts to make them green again by studying how insects collect water in one of the driest places on earth. [31]
'*Kinetic architecture,*' with a stupefying website [32] looking at new building materials responding to electrical currents, body temperature, and skeleton structures devised by Ron Resch [33] in 1970, based on folding paper techniques with the unbelievable potential to be able to build a dome without the use of big cranes or any other expensive building machines. Maybe worthwhile investigating for use in a region without building machines and a lot of pole-like construction elements like bamboo.
'*Blue economy,*' a term created by Gunter Pauli well explained in his book "The Blue Economy: 10 Years, 100 Innovations, 100 Million Jobs" [34] and his talk in Sydney [35] with special attention to acting with local people and using local products. His talk in Sydney led me to the 'Humdinger', [36] a simple device that creates electricity out of wind, and to non-rotating windmills, [37] based upon piëzo electricity. One should watch.

In the aftermath of all the above, I was invited to participate the 14th NOCMAT in Brazil, in March 2013. I had to write an abstract, then a paper. This was a first! Scrolling the Internet once more, I came across Ken Robinson, a truly gifted speaker, Kolb and Kolb with their magnificent paper about playing and learning, Huizinga again – his book in my possession since 1977, never read it – I remembered a lecture of Paul Delnooz, I have read his papers. I have also read the books of Nelis and Van Sark.

I have learned, I have come into contact with a lot of concepts and it gives me something to think about. Should we mix the course "Constructing with Bamboo" with the newly learned concept, the newly encountered magnificent things of the Internet. There is no doubt about it, we should. Because this will keep us, teachers and professor sharp, we in our exemplary role have to place ourselves on the edge of ours chairs, so students can sense the commitment, so our words are not only words.

Gaming and fun.

Before I close, I would like to take you to the Internet once more.

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[29] Arbor, A. (1963, 12). *watch?NR=1&feature=endscreen&v=GtpeWRh8Qw4*, NET Series F-155, no.1. (A. Arbor, Producer, & National Education Television) From www.youtube.com: http://www.youtube.com/watch?NR=1&feature=endscreen&v=GtpeWRh8Qw4 29:08
[30] Lipman, J. (1986). *Frank Lloyd Wright and the Johnson Wax Buildings.* Mineola, New York: Dover publications, inc.
[31] Pawlyn, M. (2010, 11). *Michael Pawlyn, using nature's genius*. (ted, Producer) Retrieved 01 17, 2013 from www.ted.com: http://www.ted.com/talks/michael_pawlyn_using_nature_s_genius_in_architecture.html?quote=897 13:47
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[33] Resch, R., & Armstrong, E. (n.d.). *page: 4 The Ron Resch Paper and Stick Film*. Retrieved 12 21, 2012 from vimeo.com: http://vimeo.com/channels/338401/page:4
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[37] mulkkim. (2008, 10 20). *Non-rotating Windmill - You Tube*. Retrieved 12 21, 2012 from www.youtube.com: http://youtube.com/watch?v=qxnalGE3Rq8

Just a few weeks ago I encountered the site of Cameron Sinclair [38] who is showing us how the Internet can come in handy to solve big problems regarding HIV and famine on the African continent.

A few months ago I came across the site 'Play the city' [39] were people, specialized in all kind of fields, professionals, are invited to play on the Internet in order to solve some urban questions that should have been solved years ago. Using in a playful manner the brains of the Internet they succeed in turning a disaster area (from an urban point of view) into a place where every city loving human being wants to live.

And last year I have come across a very interesting initiative. 'Oasis game', [40] an initiative started by Brazilian architectural students, which is spreading all over the world. We look here at a simple working method based upon dreams, own initiatives, good vibes, fun, and not based on problems, in order to solve problems that have the tendency of not getting solved rapidly. A bunch of young people who call themselves 'warrior without weapons' [41] are actually doing something for human kind by involving, in a fun way, locals to do something about their own lives and neighbourhoods.

There are a lot of ingredients, lots of techniques, lots of communication and education concepts: lectures, workshops, and laboratory tests, in the field observation, trial and error, gaming, playing, the Net … But, there are decisions to be made: where and when to play, to learn, or to do both?

Teaching is like a magical cooking course. It is like designing a taste that will never be forgotten. The lesson that takes us out of our enthrallment, that enables us to look beyond and to come up with good sustainable answers, each and every time.

An experiment.

Amidst this gathering of academics I like to ask you to view a YouTube talk. It's a message from "kid president". [42] It has been viewed over 9.514.564 [43] times. So it's kind of popular, it attracts a big crowd. It's about being awesome and taking the road less travelled. The road less travelled. I am not an academic, but here I am. I am addressing academics trying to convince them the knowledge they have deserves to be spread in a *big* way. Not only in symposia, not only at universities, not only in high schools, but everywhere. And we should do this in a funny way, so the message, we believe is so important can reach a lot of people. I know, it's an experiment, not in a laboratory, but a social one.

For me, writing this paper was, in the words of Robert Frost, the road less travelled, trying to team up with you, academics. And believe me, after a while it was "So cool!"

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[38] Sinclair, C. (2006 02). *Cameron Sinclair on open source architecture.* Retrieved 02 01, 2013 from www.ted.com: http://www.ted.com/talks/cameron_sinclair_on_open_source_architecture.html 23:34

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[42] soulpancake. (2013, 01). *www.ted.com/talks/kid_president_i_think_we_all_need_a_pep_talk*. (soulpancake) Retrieved 02 10, 2013 from www.ted.com: http://www.ted.com/talks/kid_president_i_think_we_all_need_a_pep_talk.html

[43] At 5:24 PM, Belgian time, 2013-02-10.

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