LEONARDO DA VINCI MACHINES PROJECT – APPLIED MODEL IN MOBILITY ENGINEERING

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Abstract: *Leonardo Da Vinci called a universal genius devoted his life to thousands of drawings and diagrams dealing with math, science, and engineering. That inspires today teaching by projects that engineer student may, for example, learn CAD system modeling Da Vinci´s drawings. Discussions regarding of the engineer formation and his new capacities have been the subject of research and debate in academic circles. Some engineering courses already have political and pedagogical teaching practices that address these new capacities of the future engineer. The aim of this work is to present a teaching practice by a Project Based Learning (PBL) used in a course in mobility engineering, with an interdisciplinary approach, teamwork, research and practical classes, creativity with mechanical design, very important in the education of a mobility engineer focused on vehicle systems (automotive, railroad system, naval, aeronautical and aerospace). The results validate the practice performed. An applied work in CAD system gives best complement in practice of drawing discipline.*

Keywords: *practices learning, project based learning, creativity, engineering education.*

1. INTRODUCTION

Considering the high speed of the current technological evolution, it is quite a challenge for engineering professors and lectures to keep up dated with the latest technical development, especially for non-basic classes, usually faced by engineering courses. There is a consensus among educators and practitioners that engineering education must significantly change in order to support the current world's demands. Learning-by-doing can be one important concept to hold these new world requirements (Carlson and Sullivan 1999).

Silveira (2005) said that the best way to make a ability is to expose students to activities that require contextualized (gradual and organized), we see the relevance of teaching methodologies that immerse students in an environment conducive to innovation and promote their direct contact with the world of business and industry. Sindh *apud* Rosario (2006) proved that students retain 70% of what they say and 90% of what they say and do, so it is important in knowledge building activities to involve the implementation of practical activities.

To succeed in training engineers we have answers to some questions that can help such practice as can be seen below.

What is expected of an engineer in her/his professional activity?

- To analyze the problem;
- To look for information;
- To understand this information and apply it to the solution problem;
- To exchange ideas and information within a work team;
- To take the decisions needed to apply the solutions found or to report on the work done.

But How I can prepare a engineering students for this? One method used in some engineering course are the Project Based Learning (PBL). In PBL students go through an extended process of inquiry in response to a complex question, problem, or challenge.

In Pouzada (1999) some advantages of project based learning are:

- Students are strongly motivated to work hard and effectively;
- Students learn to learn;
- There is better communications and teamwork by students;
- Students learn to work to agreed deadlines;

And some disadvantages:

- Students do not have precise knowledge of all the most advanced theories;
- The atmosphere compels students to work at the group time;
- It is a frustrating for those who find it difficult to work in groups;
- Project cost money;
- PBL requires teamwork for tutors, teachers, administrators and integration over the traditional subject boundaries.

In this general context of engineering education an educational project was proposed in a CAD course in Mobility Engineering in USFC – Joinville.

It is very interesting that we inspire our students to develop a project in a modern CAD system the fantastic invention of Renascence scientist, artist, engineer Leonardo Da Vinci. This is an example that a genius can promote innovation many centuries ago his time.

In practice, it means give the students the opportunity to learn new technology understanding the history of the machines invented by Leonardo and nowadays are well applied as creative devices that may studied as part of engineers formation like we know as machine elements, robotics, mobility engineering, and so on.

With the focus of the course of mobility engineering we select Da Vinci's machines that have close relation with aeronautic, automobilist, naval and railroad system. As example in last days of his life, Leonardo studied the fly of the birds as an important area nowadays known as bionic.

The great challenge for the students was translate the Da Vinci´s drawings for actual concept of technical drawing learned during the classes of CAD.

2. PROJECT EXECUTION

2.1 Leonardo Da Vinci

Leonardo was born in Anciano on April 15, 1452, a small Tuscany village near Vinci, located in the vicinity of Florence. He was an Italian polymath from painter, scientist to writer and most diversely talented person ever to have lived. Renaissance inventor of insatiable curiosity explored the usual empirical method for his time.

In 1460 moved with the family to Florence where he was educated by the renowned painter Verrochio. Although he was her apprentice painter, in this time Leonardo becomes interested in military devices. Spent much of his lifetime living in Milan serving Ludovico il Moro. Times after worked in Rome, Bologna and Venice and French King Francois welcomed him at the end of life as his first royal engineer. (NULAND, 2001).

With Mona Lisa and The Last Super became a renowned painter. Beyond his artistic works he contributed to later generations of artists, engineers, scientist, medical professionals with his notebooks containing drawings, scientific diagrams and his thoughts on the nature of painting.

Some of his designs were not constructed and there was no technology to implement them. As amazing inventor he gave conceptual foundation of devices like helicopter and tank and of manufacturing concepts like automated hobbin winder and machine for testing the tensile strength of wire are part of current practice.

As recognized engineer he created al sort of machines for war like a tank. Invented musical instruments, hydraulic pumps, reversible crank mechanisms, and so on. In civil engineering projected many bridges and in phenomenon of flight produced many studies of the flight of birds (Codex on the Flight of Birds) registering plans of several flying machines like a light hang glider and a helicopter.

As a scientist, was responsible for major advancement of knowledge in the fields of anatomy, civil engineering, optics and hydrodynamics. Leonardo is considered by many the greatest genius in history, due to his multitude of talents in arts and sciences, their ingenuity and creativity, and his polemical works. In a study in 1926 his Q.I. was estimated at about 180. (Pinto, 2006)

Actually the Leonardo´s machines are built and tested according to his original designs in a Universities and TV shows. Also there are robot technology problems involve Leonardo's machines like the book "Advanced NXT – The Da Vinci Inventions Book" from Scholz (2007). In this book, it possible to revive devices as the flying machine, the aerial screw, the revolving bridge, the double leaf spring catapult, and the armored car, five centuries after their creation by the great Renaissance engineer.

In a funny way you can learn much more about Leonardo Da Vinci life in Cox (2006) book "Leonardo Da Vinci and his super-brain". In a vision of an art critic of Leonardo's war machines and as the first engineer of the renaissance was known as the "prophet of automation" (Vezzosi, 2006). An current illustrated Leonardo's biography we can find in Séailles (2010) book the judgment of Vasari of the follower "he says how much he has offended God and men in this world, by not having worked at his art, as he should have" and illustrations of inventions and the time that it happens like Vertical Flying Machine (1487-1490) and Different Types of Chains (1493-1497) that is no ease to find. The evolution of machine design methodology from the Renaissance to the Age of Machines in the 19th century is examined in Moon (2006) book. It provides detailed analysis, comparing design concepts of engineers of the 15th century Renaissance and the 19th-century age of machines from a workshop tradition to the rational scientific discipline used today.

2.1 Leonardo's Machines Project

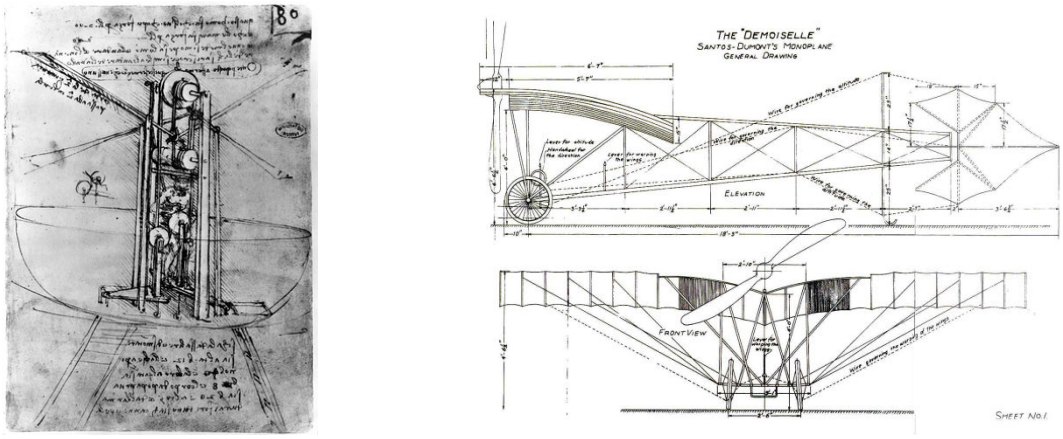
The Leonardo's Machines Project based in a Project Based Learning was development in a CAD class named in our Mobility Engineering as Design and Geometric Modeling. In the first two semesters we have 4 hours in a week to give sketching drawing and basic CAD system concepts. The last project we adopt the method of giving one mouth to

modeling a device invented by Leonardo Da Vinci with reasonable complexity. Give more than a mouth is now our normal classes planning and a reduction to 3 hours a week could be justified due a political pedagogical project update.

The work must be presented in an academic format using scientific methodology in the beginning of the course to be natural in developing project in the Mobility Engineering course.

Each students group was organized involving functions in a Design Group, each as: Director, Designer (2D and 3D), Searcher and Product Designer. The teams are free to choose the Leonardo's Machine to study, design using a CAD system and build a prototype. In the first semester of 2011 we added a Modeler function to divide work and to demonstrate that a physical model is an important a complex activity principally for initial stage of the course.

The second time in applying Leonardo's Machine Project we added Santos Dumont flying machines in response to requests from students. In Fig. 1 we can see the drawing of Leonardo Da Vinci (Fig. 1.a) and Santos Dumont (Fig. 1.b), observing that there is no dimension in Leonardo's drawing and technical drawing of Santos Dumont it's easer do implement in a CAD system. There are many sketches made by Leonardo in flying machines and systems and experiments as his fascination by phenomenon of flight.



(a) (b)

Figure 1. Flying machine drawing and a model in a CAD system (Solidworks): (a) Leonardo Da Vinci (Flapping wing) and (b) Alberto Santos Dumont (Demoiselle)

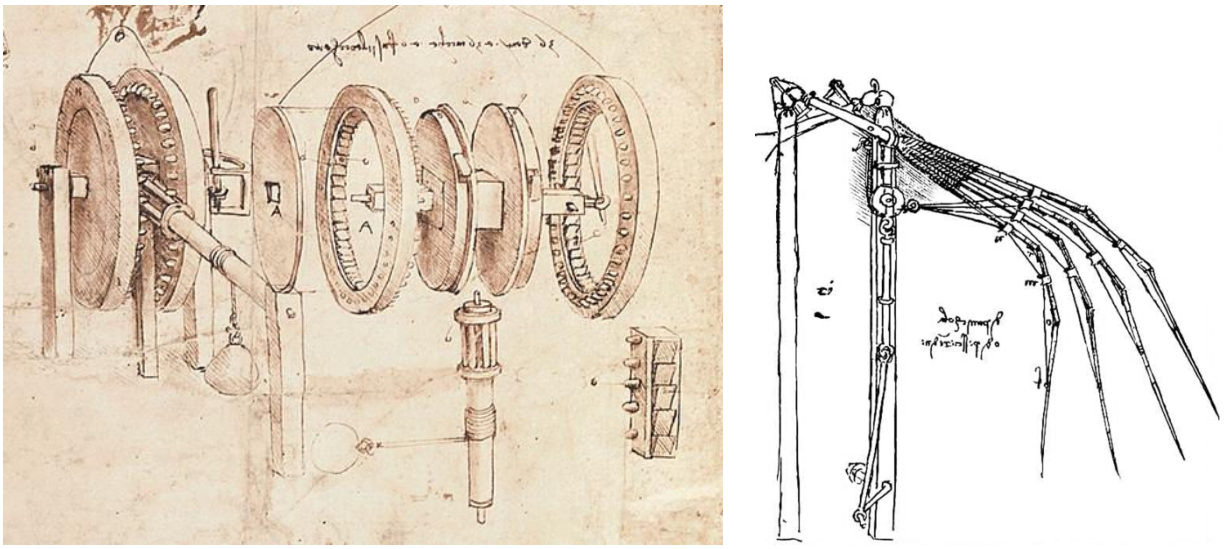
Table 1 show the proposed themes to the last three semesters. There are different machines that Da Vinci invented or only draw and never were built. These choices were based in machines that could have any relation with mobility engineering like flying machines, boats and other vehicles drawings of Leonardo's creative genius. We identify that that there is a culture to reproduce Leonardo's invention as can be seen in YouTube site that models are reproducible by step by step instruction video.

Table 1. Selection of project in 2010-2011.

First semester/2010	Second semester/2010	First semester/2011
Automaton or robot	Vertical Ornithopter	Revolving bridge
Aerial screw	Ornithopter	Canal excavating crane
Ornithopter	Armored Car	Paddleboat
Flapping Wing Experiment	Revolving bridge	Articulated wing system
Two leaf spring car	Paddleboat	Mechanical wings
Revolving bridge	Ship with sickle (scorpion)	Flying machine
Canal excavating crane	War chariot to attack the surrounding wall	Ornithopter
Boat Shield	Archimedes screw water pump	Dredger
Armored Car	Bicycle	Bicycle
Revolving bridge	Catapult	Automaton or robot
Archimedes screw water pump	Mechanical drum	Reciprocating motion machine
Scuba Gear	Giant Crossbow	Odometer
Bicycle	Dirigíble Ballon	Crane
Multi-barrelled Machine Gun	14-Bis	Catapult
	Demoiselle	Spingarde - field artillery gun

Some invention are in practical application and could be used day by day that continues to used today based in his ideas like crane, bicycle, etc. (Fig. 2a). But some of them are searching of an area in a time there restricted technology

in materials, process, machines, mechanical principles that could not constructed and nowadays is reality like the man can fly in moderns flying machines (Fig. 2b) mankind dreams. There is a great relation in the invention of fundamental mechanism system like reciprocating motion machine, gears, etc. and is fundamental to discipline like Mechanism, Machine Elements and Dynamic that be identified in reference Moon (2006) book.



(a) (b)

Figure 2. Examples of Leonardo Da Vinci invention drawings:
a) Reciprocating motion machine and (b) Articulated wing system

We proposed to divide Da Vinci's Machines an Inventions selected to developing a new reading in:

- Flight Machines: Mechanical wings, Vertical Ornithopter, Flapping Wing Experiment, Ornithopter.
- War Machines: Armored Car, Multi-barrelled Machine Gun, Spingarde - field artillery gun.
- Mechanics: Odometer, Canal excavating crane, Robot.
- Hydraulics: Archimedes screw water pump, Paddleboat.
- Interactive Models: Reciprocating motion machine, Flapping Wing Experiment.

We suppose that the CAD model were implemented by the students specially by the most wise student and eventually by the much more interested in learning this important tool. But as Joinville's Campus of UFSC doesn't have an adequate structure to implement a physical model were constructed in a creative manner using any kind of material, like recycling material were allowed to be explored. It can be found in the web different developed models, based on the Da Vinci codes and on historical documents using the materials of Leonardo's time: wood, metal, ropes and fabrics (Le Macchine di Leonardo, 2011).

Figure 3 shows an identification of other the projects developed by the students to help to explain the project to the public in a organized exposition. In Fig. 3a some description of the machine or invention of Leonardo Da Vinci were made and in Fig. 3b and the 3D virtual model is represented in a rendered montage.

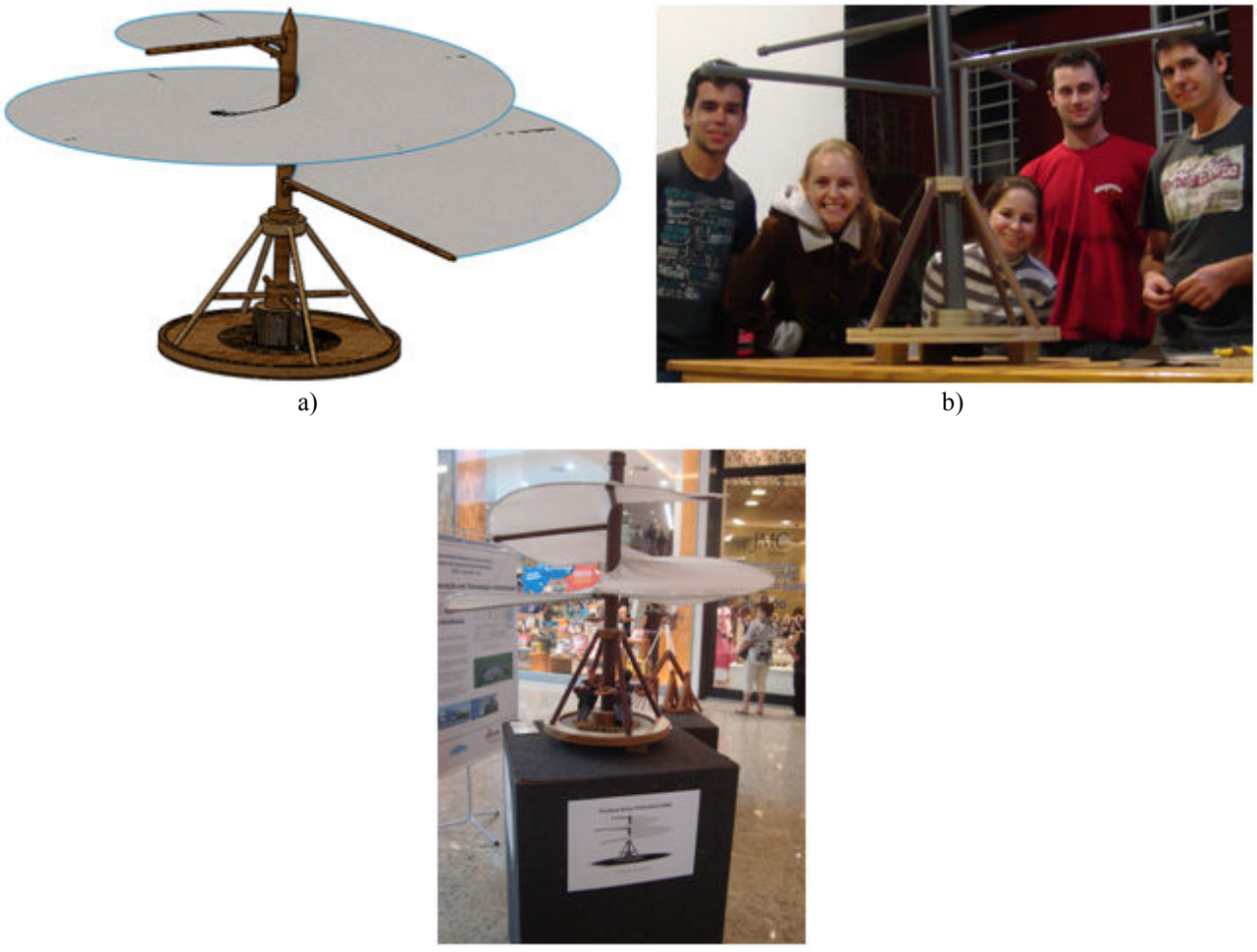
(a) (b)

Figure 3. Identification of the project to exposition: (a) memorial and (b) rendered virtual model.

2.2 Results

Some Leonardo's Machine development in 2010 was: automaton, aerial screw, flapping wing, two leaf spring car, revolving bridge, flying machine, boat with sickle, war car, bicycle, catapult, Archimedean screw, dredge and tank. Pictures of the teams that participated in the Leonardo Da Vinci´s project may be consulted in the institution site (CEM, 2010).

In Fig. 4 the Aerial Screw project is present as an example. This machine is one of the most famous projects from Leonardo's genius. In Fig. 4a is shown the CAD model, in Fig. 4c the prototyping and Fig. 4b shows the student group with a build version of the Aerial Screw, more closely related to the original drawings. This model has been rebuilt observing the smallest details from the spring loaded by the push of four men, up to the flywheel that rendered the duration of the spin longer. A system end with an oral presentation and delivery of the report and the digital drawing. After this presentation the machines are exposed in the University hall. The exhibition of the university community for highly motivated academics, as well as shows at the University was invited to exhibit work in a large commercial center of town, making friends and relatives to see the project done.



a) b)

c)

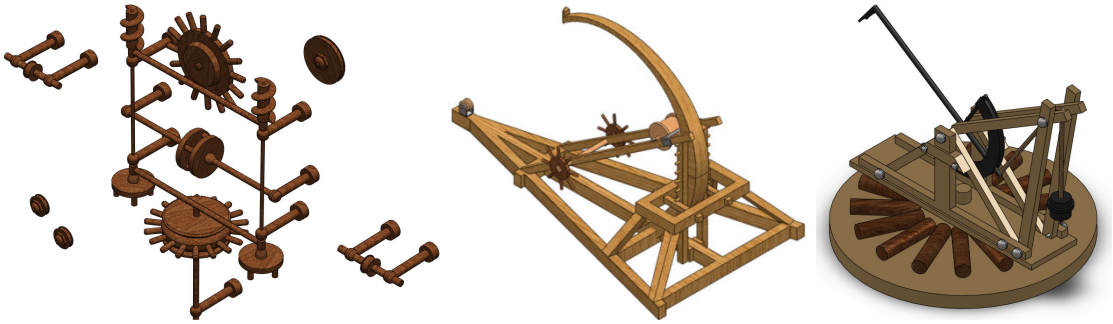
Figure 4. Example of the Leonardo's machines project. (a) 3D CAD model; (b) physical model in construction by student group and (c) complete model in a shopping center exposition.

In giving some sketches to identify the Leonardo's machines we only chose his original drawings. This was part of the documented proposed classes project title "Leonardo Da Vinci Machines Project" that was oriented to be exposed in a public place for the community in a cultural event that is placed in regional journal (Fig. 5) to divulgate the university activities and the student's works.

Figure 5. Picture of organizer of "Leonardo Da Vinci Machines Exposition" in A Notícia Journal .

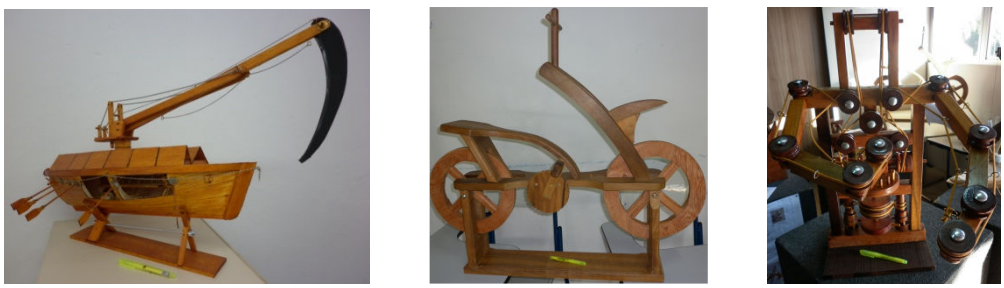
It can be identified the best works that have excellence in group implement physical model based in virtual model developed in consecrated powerful CAD system like SolidWorks. Figure 6 shows some of the best CAD models of the three semesters and Fig. 7 some physical models.

As creativity and originality prototype construction we can see in Fig. 8 the results of some Da Vinci's projects were several modifications to facilitate de construction based on original plans depicted as not clear sketches and design with serious flaws that students in early stage of course couldn't identify showing the importance of developing some project to complement classroom content.



(a) (b) (c)

Figure 6. Ones of the best 3D CAD models of Da Vinci's machines are:
(a) Robot; (b) Catapult and (c) Canal Excavating Crane



(a) (b) (c)

Figure 7. Some of the best physical models of Da Vinci's machines:
(a) Ship with sickle (scorpion); (b) Bycicle and (c) Robot.

(a) (b) (c)

Figure 8. Some original physical models of Da Vinci's machines:
(a) Tank; (b) Odometer and (c) Crane

3. CONCLUSION

With the development of the Project Based Learning described in this article, we noticed a significant shift in interest from the academic engineering during the school year, where they are more motivated and interested in the proposed activities. Another analysis that must be observed is the development of activities of teamwork, which is of great importance, because, living and working together to improve information exchange and knowledge construction, developing the organization as well as a team to meet goals and deadlines.

We tried to make this work aiming a stimulus to creative work with the students of first year engineering content not only from the basic engineering disciplines (mathematics, physics and chemistry) but subjects them to develop innovative capabilities. The result was reasonable in short time to apply many CAD concepts and complement machine element based in five centuries ago inventions widely adopted.

In spite of there are no laboratory (machete) the students with their partners (parents, artesants, etc.) had success in rebuilt Leonardo´s physical model. But, most of them have had only success in virtual model with the ability in constructing a virtual model. There are no direct relations in physical and virtual model quality. It means that some groups could have facility in implementing a 3D CAD model and difficulty in construct a prototype.

Some students extend their work making dynamic animations in the adopted CAD system and specifically in Dynamic classes apply concepts of this discipline in the CAD model.

3. ACKNOWLEDGEMENTS

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