Principles of Web Digital Dynamic Usability

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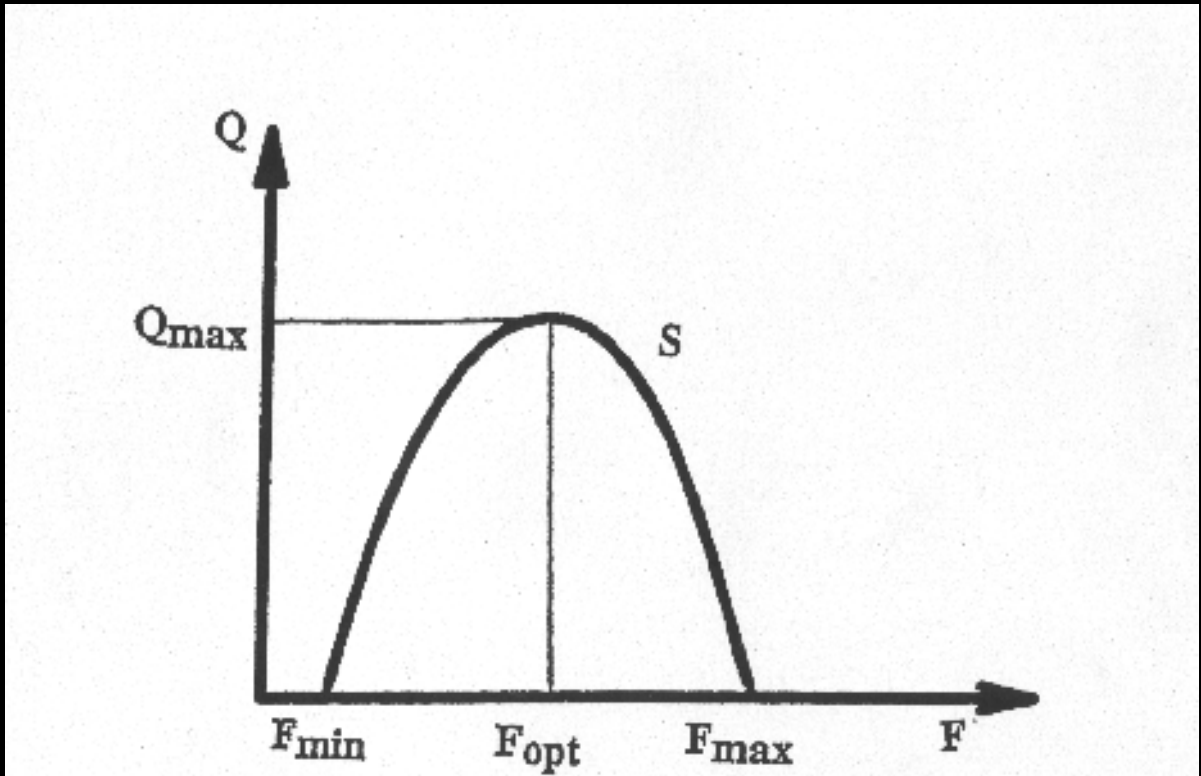
Introduction

- In my Keynote Address for the Congress of International Ergonomics Association IEA'94 in Toronto the three laws of ergodynamics were proposed.
- The laws proved to be important for development of a new web usability methodology, a Digital Dynamic Usability.
- Here are the laws:

Fundamentals of ergodynamics

- Ergodynamics Law #1

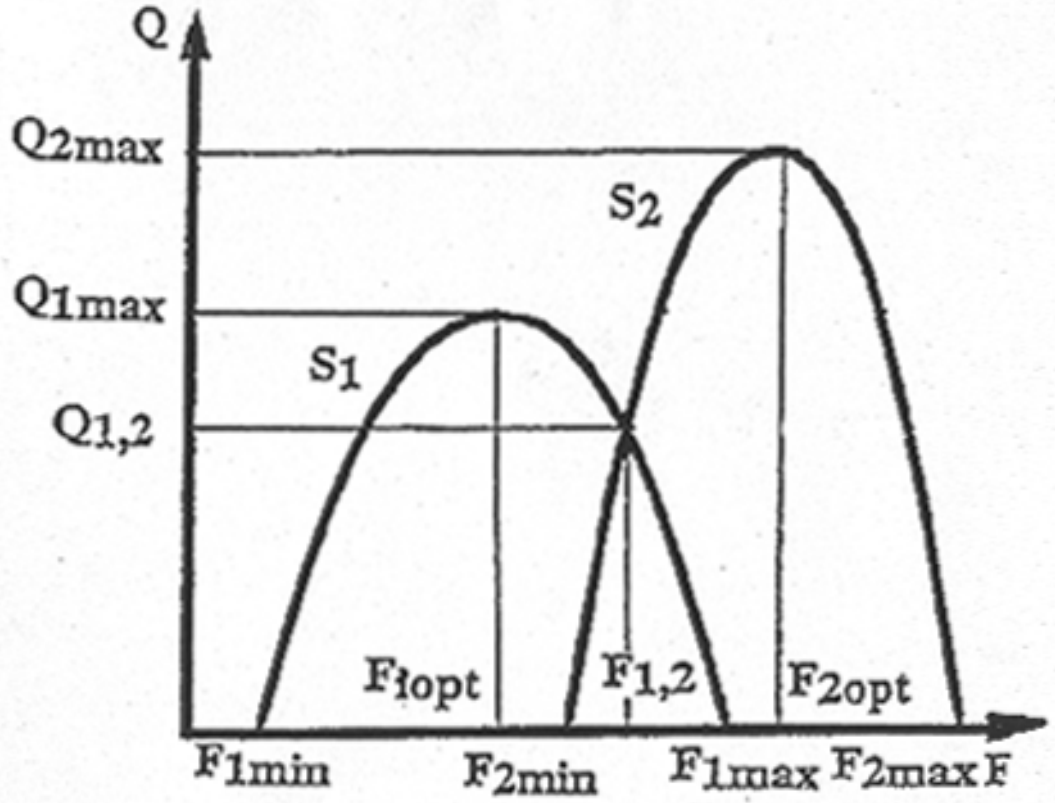
- *Work efficiency is a bell-shaped function of any work factor.*



Visualization of the Law #1 of ergodynamics

Fundamentals of ergodynamics

- Ergodynamics Law #2
- *Every work task can be done using different work strategies. Every strategy is presented as a separate bell-shaped efficiency function on every work factor.*

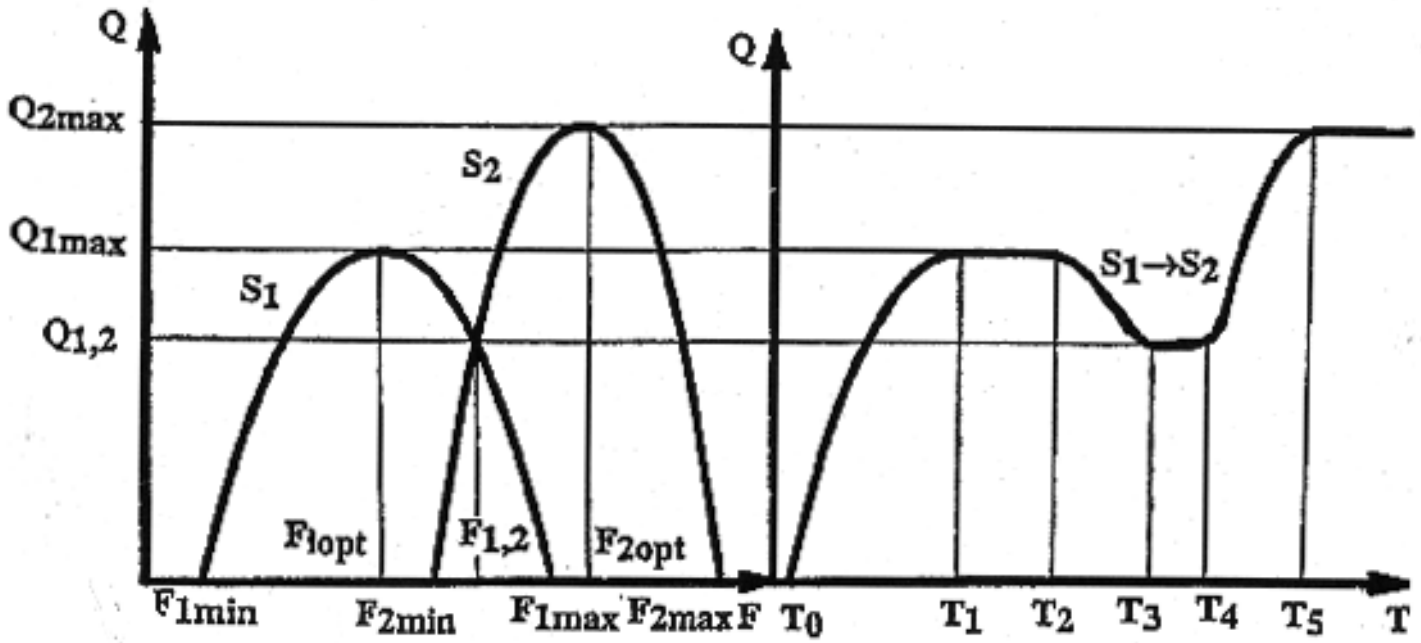


Visualization of the Law #2 of ergodynamics

Fundamentals of ergodynamics

- Ergodynamics Law #3

- *Efficiency of interaction or transformation between two strategies is defined at the intersect point of the bell-shaped functions for the strategies.*



Visualization of the Law #3 of ergodynamics

Outline

- 1. Digital Dynamic Usability of web sites
- 2. Predictive models of business development and transformations
- 3. Usability testing, invention and design of electronic assembly workstations
- 4. Models of human-machine-environment interaction
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1. Digital Dynamic Usability

- Limitations of existing web usability:
- Existing usability methods are based on implicit assumption that a usability tester (participant, user) and a product (web site, hardware or software) are not changing essentially and thus the usability process is a static one. It is not true.
- Qualitative and static oriented usability methods are not adequate to web using, web access, training, rehabilitation and to any other real dynamic process of human-machine-environment interaction and mutual adaptation.

marchFIRST: innovation and leadership in web usability

- Practice in current dynamic world, particularly in e-world, which the marchFIRST is designing, requires a digital and dynamic usability based on new methodological principles.

- **marchFIRST Phoenix Usability Center** is developing and providing a new, digital dynamic usability methodology based on the foremost achievements of ergonomics, human factors and ergodynamics.

Fundamentals of a Digital Dynamic Usability

- 1. General Principles
- 2. Methodology of analysis of the users' cognitive strategies in work with website.
- 3. Possible misrepresentation of the real users' performance in the usability experiments.
- 4. Usability factors: distinguishing and quantitative analysis.
- 5. DDU principles and recommendations: optimization of the usability factors.

Limitations of the existing usability methodology

- **Why existing usability methodology is not sufficient for web design?**
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- **1)** Existing web site usability testing methodology is mostly based on qualitative analysis of user-web interaction.
- **2)** The methodology does not take into account cognitive strategies applied by the users and dynamic transformations between the strategies.
- **3)** The usability testing does not provide concrete recommendations and quantitative predictive models for website information architecture (IA).

Digital Dynamic Usability

- **What is a Digital Dynamic Usability (DDU)?**
- Digital Dynamic UIA is an innovative **addition** to the existing methodology of usability and IA, which provides the following improvements:
- 1) Use of **quantitative measurements** of the web usability **criteria and factors**;
- **2)** Produce specific recommendations for IA based on analysis of the **differences between optimal and actual values of the criteria and factors for different cognitive strategies of the website users;**
- 3) Use fundamental principles of **ergodynamics** and **predictive models of user-web site dynamic interaction, mutual adaptation and transformations in users' cognitive strategies**.

Usability Center at marchFIRST

The goal of the Usability Center at marchFIRST Inc. is to further improve methodology of usability and IA of websites based on:

1) Development of general principles of DDU

2) Quantitative measurements of the actual values of the web usability criteria and factors using objective registration of user's performance and specially designed questionnaires of an "indirect" type to prevent influence of subjective bias,

3) Analysis and comparison of actual and optimal values of the efficiency-complexity factors for different cognitive strategies of the website users,

4) Development of IA principles and concrete recommendations on optimization of the most influential efficiency factors for different cognitive strategies of the website users,

5) Development of predictive models of user-website mutual adaptation and increase of user's performance

Digital Dynamic Usability Methodology

- The Digital Dynamic Usability methodology is based on the principles of the ergodynamics, which is relatively new area of human factors and ergonomics presented particularly in
- Venda, V. F., and Yuri V. Venda,
- Dynamics in Ergonomics, Psychology, and Decisions: Introduction to Ergodynamics. Ablex Publ. Corp., Norwood, N.J., 1995.

Principles of Digital Dynamic Usability

- DDU Principle #1.

- ***For a certain website user's cognitive strategy every usability efficiency criterion, Q_i, is a bell shaped function of every usability efficiency-complexity factor or usability factor of human-website interaction and mutual adaptation, F_j.***

Principles of Digital Dynamic Usability

- DDU Principle #2. Principle of plurality of cognitive strategies

- ***Users may use different cognitive strategies while using the same website. Each user's cognitive strategy is presented with a corresponding bell-shaped function for usability efficiency criteria and a U-shaped function for UCC.***

Principles of Digital Dynamic Usability

DDU Principle #3. Principle of user-website interaction efficiency.

If website designer is adapting the website to a cognitive strategy S_1, but the users are using a different cognitive strategy S_2, then a value of efficiency criterion of interaction between user and website is determined at an intersect point of the bell shaped functions (curves) for S_1 and S_2.

Principles of Digital Dynamic Usability

DDU Principle #4.

Principle of transformation efficiency.

If a user is previously trained to use cognitive strategy S_1 but a website requires the user to learn and use S_2, then a lowest value of usability efficiency criteria usability efficiency criteria during transformation of S_1 into S_2 will be determined at an intersect point of the bell shaped functions (curves) for S_1 and S_2.

Usability innovation at marchFIRST

Usability Center at marchFIRST Phoenix Office is developing and implementing the new methodology of the web usability and information architecture, Digital Dynamic Usability based on the General Principles of Ergodynamics

Usability innovation at marchFIRST

The new methodology provides advanced results based on

1. **quantitative measurements of the actual values** of the web usability criteria and factors;
2. analysis and comparison of **actual and optimal values of the efficiency-complexity factors for different cognitive strategies** of the website users,
3. development of IA principles and **concrete recommendations on optimization** of the most influential efficiency factors for different cognitive strategies of the website users,
4. **development of predictive models** of user-website mutual adaptation and increase of user's performance.

Cognitive strategies

Cognitive strategies used by web site usability testing participants and by web site users

Our experiments confirmed that user-web interaction efficiency is bell-shaped function of different factors characterizing the web site. In accordance to the Principle #2 each web site might be perceived by the users using different cognitive strategies.

Cognitive strategies

If usability tests are done with participants using a cognitive strategy different from those typical for the actual users, the results of the usability tests may be useless or even wrong and harmful for further use in the information architecture and web design. Optimization of the web site for the participants may lead to worsening usability of the web site for the actual users.

Analysis of users' cognitive strategies

Interval of the factor values between optimal values of the factors for the cognitive strategies of participants and actual users is a special importance. In this interval improvement of web site for the participants leads to decrease of performance efficiency for the actual users.

Therefore it is mandatory to find out types of cognitive strategies used by the web site users and pick the participants with identical cognitive strategies.

Analysis of users' cognitive strategies

Distinguishing cognitive strategies

In the experiments on user-graphic information interaction, using eye movement registration, we identified three basic cognitive strategies:

1. Perception of information by separate elements (like reading "by letters") Sl,
2. Perception of information by small groups (2-3) of elements ("syllables") Sy, and
3. Perception of information by larger groups (4-7) of elements ("words") Sw.

Analysis of users' cognitive strategies

The participants' performance was analyzed using eye movement registration, EEG recording, self-reporting, questionnaires, larynx myography, and time and error analysis.

Using DDU Principles we defined and modeled cognitive strategies with corresponding bell-shaped functions *Qbi(Fj)* where *Qi* is a user's performance efficiency if the *i*-th strategy is actually used, and *Fj* is one of the usability factors.

Quantitative analysis of the usability factors

Unlikely traditional psychological studies based on qualitative characteristics of cognitive strategies (Norman, 1986), our DDU methodology is directed to use of the operational and quantitative characteristics of the cognitive strategies based on analysis of interrelations between usability criteria and usability factors.

Quantitative analysis of the usability factors

We need to stress that in studying cognitive strategies and user performance efficiency usability specialists must define an actual number of information elements perceived and processed and not a number of the information elements displayed at the website.

Quantitative analysis of the usability factors

It is also important to find out how the elements were perceived: separately, by small groups (“information chunks”) or by larger groups.

The performance is most effective if the number of elements and the size of information chunk perceived simultaneously are equal to the optimal ones for the concrete user’s cognitive strategy.

Quantitative analysis of the usability factors

Here are examples of the specific usability factors used in usability testing, assessment and design of computer graphic information:

F_1 - a number of information components displayed on the screen, related to the problem and actually perceived by the user during solving the problem (task).

F_2 - a number of information chunks actually perceived by the user during solving the problem (task).

Quantitative analysis of the usability factors

F_3 - an average number of information elements in the information chunk perceived by the user simultaneously.

F_4 - a number of the user's eye movements during the problem solving.

F_5 - an average angle of the eye movements during the problem solving.

F_6 - an average eye fixation duration during the problem solving.

F_7 - the most long eye fixation duration during the problem solving.

Quantitative analysis of the usability factors

F_8 - a number of the most important (critical for the problem solving) information elements displayed on the screen, related to the problem and actually perceived by the user during solving the problem (task).

F_9 - a total number of information components perceived from the screen and obtained from memory and other sources that the user processed during solving the problem (task).

F_{10} - a total number of the links between information elements displayed on the screen, which the user involved into solving the problem (task).

Quantitative analysis of the usability factors

F_{11} - a number of direct (obvious) links (relationships) between information elements displayed on the screen, which the user involved into solving the problem (task).

F_{12} - a number of indirect (hidden) links (relationships) between information elements the user considered during solving the problem.

Quantitative analysis of the usability factors

Totally we studied 19 usability factors. In each case it was enough to measure 5-8 most influential factors in order to reach value of correlation coefficient about 0.75-0.9 and find concrete and sufficient recommendations on improvement of information architecture.

Quantitative analysis of the usability factors

The numerical values of the usability factors are defined using objective registration (e.g. eye tracking system), questionnaires and participants' self-reports.

The questions used to define and measure usability factors as a rule must not contain any direct questions about advantages and disadvantages of the website to be assessed in the usability testing. This is very important in order to eliminate any influence of participants' or experimenters' bias.

Quantitative analysis of the usability factors

Quantitative analysis of the usability factors which cannot be objectively measured is based on indirect questions about the website.

This is also way to automation and improvement of productivity of the usability testing.

DDU Principles in application to graphic information design

The following principles of graphic display design were found while studying influence of the efficiency-complexity factors on major criteria of users performance efficiency (speed and reliability) and complexity (time spent and number of errors made) *(Venda, 1975, 1982, Venda & Venda, 1995)*

1. *The optimal laconism principle: a number of information components of the page must be minimized up to the optimal information volume to allow maximal efficiency and minimal complexity of the task solving process.*

1. The *autonomy ("stand-alone") principle*. In many cases designer cannot reduce the number of information components to the optimal amount. Complexity of the information perceived may be then reduced if the components are combined in functionally connected groups and the groups clearly visually divided each from other, even if designer must reduce sizes of the components inside the groups.

1. The *principle of generalization and unification. Web pages often contain many small insignificant details and various symbols. As a result users* devote too much attention to minor items. Perception process complexity is increased as a result of large numbers of various symbols coding similar items, phenomena and relationships. The principle of *generalization and unification* of data items may help web designers to reduce a set of symbols used.

1. The *principle of visual accentuation of symbols* displaying the most significant data. Conversely, one should displayay secondary items on a screen by symbols with smaller dimensions and less color contrast.

1. The *principle of a spatial consistency of location of functionally similar data on the screen.*
2. The *principle of detailed and integral data separation*— the data that user needs at different decision stages must be clearly divided. Designer needs to separate such data on the screen either in space (simultaneous presenting in different zones of the screen) or in time (sequential presenting).

1. The *information chunking principle,* i.e., placing data items into groups by giving them easily memorized and clearly distinct forms to distinguish them as a simultaneously perceived from other groups.

2. *Perfect information chunk composition principle*. Use of technical aesthetics, industrial design or *art composition techniques helps to decrease complexity of the simultaneous perception of larger information chunks.*

1. *Use of special graphic composition to better organize information perception process, to determine more smooth eye movement and data scan routes.* This helps to find graphic contours and logic links to focus the user's attention on a data directly related to the sequence steps in the problem solving process. This is an effective way to reduce the complexity of the task solving and increase aesthetics of the web page and any other graphic composition (Kazimir Malevich, 1923, 1936).

1. *Graphic display of the process pre-history to help predict further dynamics and steps in problem solving.*
2.

Principle of command-information display. New knowledge about task may be directly combined with commands on the task solving process.

1. Using methods of on-line behavior analysis web site may be adapted to the users on the following levels consequently increasing accuracy of adaptation and efficiency criteria of the users' performance: total level, contingent (staff) level, group level, individual level and the most precise, an individual-operative level (adaptation of the information to the current state, task and problem solving process) (Venda, 1975, 1982, Venda & Venda, 1995).

1. Use of artistic composition methods is very important to attract and keep the web site users. The focus of a display format composition is to find a whole and its component elements, and to choose the main and subordinate composition centers. A vital condition of composition completeness is the equilibrium of the parts with the main center. The composition depends on the level of adaptation to the users chosen by the web designer.

1. More often, the verticals and horizontals make up a display format's composition axis. These may be lines, dots or compact blocks of data, or object images and their parts. The user's eye, searching for a required signal or symbol, or monitoring an investigated production process, should not make chaotic movements. These movements should be orderly. They should proceed in step with the customary horizontal and vertical shifts. The number of these shifts should be minimal.

1. When designing a display format, one should appraise the biomechanics of the eyes, specifically, that horizontal movements are the easiest and fastest to perform. Eye movement velocity on a curve depends on the shape of this curve and it varies widely.

Web page composition must be based on simple and easily recognizable visual rhythms. Art composition theory knows of two recurrence patterns-- metric and rhythmic. Rhythmic patterns offer the most interesting composition possibilities.

Besides the ordinary meter, usually subject to rhythmic changes, rhythm implies also the regular change of some characteristics: of the distances among constituent elements, their number in groups, their forms, dimensions, etc.. The intervals among the elements play the same role as do pauses in music. Besides, if one introduces accent-- i.e., amplifying certain elements-- it would emphasize the rhythm. Designer may generate rhythm by lines with an identical slope, by distinct groups of mnemonic symbols, concentric circles and other figures, alternating at equal or regularly changing intervals. The finality of a rhythmic order depends on how “the rhythm is stopped”, that is, what the final order's elements look like. The latter, like a musical phrase, cannot be interrupted at will. But the difference is that one always reads the musical phrase in one direction, while perceiving visual data depends on the perception logic and process.

To have rhythmic order finality, one may use these devices on a display format: Increasing the intervals before the final element groups (final “tact's”); Intensifying the accents on the central groups by auxiliary characteristics (the size of symbols, their color, etc.); Introducing the foreign elements, e.g., special large symbols, into the final groups; Integrating the final elements into groups of an inchoate new rhythmic order consonant with the main one.

Contrast and shade are important composition factors. Most often one may reach the required format element distinction by a functional analysis of the elements, and of their role in the visual perception, comprehension of information and problem solving.

There is an important artistic composition meaning of shade and contrast being used in display format designing. First, shade and contrast enhance an image's aesthetic qualities if and only if they accentuate and complement other composition techniques and are not at odds with the latter. Second, shade and contrast may operate as independent means of functional attributes of the format elements. Third, one can have mutual transitions between shade and contrast-- to lend more dynamics to the image.

As a rule, shade and contrast are simultaneously present in a composition solution, for one of these two devices accentuates and intensifies the other. One can increase the effect that the contrast between the main signal and the background exerts on the student by a shade ratio between the background and the secondary elements. The most difficult composition-related question is to choose a proper web page format scaling and its composition elements.

1. The format is, on the one hand, a “small form.” It is an independent object of perception of comparatively small dimensions; still, this independence is relative, since the pages of the web site are interconnected and used in various sequences.

Conclusion-1

- Fast growing web usability and design require new methodology of studies of user-graphic information interaction to be developed and implemented.

Conclusion-2

The laws of ergodynamics and principles of digital dynamic usability were suggested and successfully used to develop methodology of the digital dynamic usability.

Conclusion-3

World leader in business integration and web design, marchFIRST started extensive work on development and use of the Digital Dynamic Usability methodology which adds to existing methods such important features as objective registration of user performance, quantitative measurement of performance efficiency factors and criteria, analysis of cognitive strategies, models to predict results of usability tests and web design and concrete recommendations on information architecture and web design starting from early stages of the projects.

Invitation to cooperation with marchFIRST

- We are inviting colleagues, partners and clients to cooperate on further development and implementation of the Digital Dynamic Usability to the web design.
- This invitation goes particularly to the colleagues at various marchFIRST offices and to the members of our worldwide network, the International Institute of Cognitive Psychology, Ergonomics and Hybrid Intelligence Systems, who live and work in USA, France, Norway, Germany, Russia, Ukraine and other countries. New members are welcome.
- Now the center of the Institute/Network is at **marchFIRST, Phoenix Office.**

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