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# The WEB 2.0 induced paradigm shift in the e-learning and the role of crowdsourcing in dental education

Thurzo A[1], Stanko P[3], Urbanova W[4], Lysy J[1], Suchancova B[1], Makovnik M[5], Javorka V[2]

*Department of Orthodontics, Department of Dentistry and Maxillofacial Surgery, Faculty of Medicine, Comenius University and St. Elisabeth Institute of Oncology, Slovakia.* **AndrejThurzo@hotmail.com**

**Abstract:** *Objectives:* Authors evaluated the effect of the WEB 2.0 environment on dental education and estimated the difference in retention of knowledge by cephalometric analysis in orthodontics between conventional education and off-line e-learning.
*Background:* Five years of experience with complex web-based e-learning system allowed the evaluation by retrospective analysis and on-line questionnaire.
*Results:* The results revealed the current trends in on-line behavior of students based on the WEB 2.0 innovative technologies like Ajax. Results confirmed an increasing number of resources with a rising frequency of e-learning materials.
*Conclusion:* The study confirmed that e-learning of the same subject is more efficient in immediate examination after the lecture with even better results after 12 and 24 months against the control group *(Tab. 3, Fig. 1, Ref. 26)*. Full Text (Free, PDF) *www.bmj.sk.*
Key words: dental education, e-learning, dental informatics, crowdsourcing, Web 2.0, knowledge retention.

**Abbreviations:** IP address – An Internet Protocol (IP) address is a numerical identification that is assigned to devices participating in a computer network..MAC address: Media Access Control address (MAC address) is a quasi-unique identifier assigned to most network adapters by the manufacturer for identification. WEB 2.0 – second generation of web development and design, that facilitates communication, secure information sharing, interoperability, and collaboration on the World Wide Web.

Is the current evolution of Internet actually changing the paradigm of education? Is the e-learning 2.0 a substantial change from traditional informative concept of on-line education? How could a dental education benefit from the crowdsourcing? Has the use of on-line e-learning a positive effect on the quality and retention of knowledge of pregradual dental students or is it just a purposeless race in the implementation of new a technology?

Imagine that your students learn mostly from each other and that this "crowd" becomes a more efficient source of teaching than you. Over the past several years people from around the world began exhibiting an totally unprecedented social behavior: they were coming together to perform tasks, usually for no financial interest. There is a rapid increase in the use of web-based ‚collaborationware' in recent years. These Web 2.0 applications (*wikis, blogs, podcasts*.), have been increasingly adopted by many on-line educational services (1). Web 2.0 is a term describing new collaborative Internet applications. The primary difference from the original web is a higher user participation in developing and managing content, which changes the value of the information. The medical community needs to be aware of these technologies and their increasing role in providing education and health information (2).

*Lesson Design*

Imagine if you had the time to create a complex pregradual e-learning course consisting of all dental fields like orthodontic, prosthetics etc. This is a great idea, but the reality is that teachers do not have the time to research all these areas and connect them. But the "crowd" does. Hundreds of students with an interest in literacy and lesson design could choose areas of interest and create amazingly interesting, deep, connected, and focused lessons. Imagine a "lesson plan site" where people create les-

[1]Department of Orthodontics, Department of Dentistry and Maxillofacial Surgery, Faculty of Medicine, Comenius University and St. Elisabeth Institute of Oncology, Bratislava, Slovakia, [2]Department of Conservative Dentistry, Department of Dentistry and Maxillofacial Surgery, Faculty of Medicine, Comenius University and St. Elisabeth Institute of Oncology, Bratislava, Slovakia, [3]Department of Maxillofacial Surgery, Department of Dentistry and Maxillofacial Surgery, Faculty of Medicine, Comenius University and St. Elisabeth Institute of Oncology, Bratislava, Slovakia, [4]Dental Department, 3rd Medical Faculty Charles University Faculty Hospital Royal Vineyard, Department of Orthodontics and cleft anomalies, Prague, Czech Republic, [5]University Hospital, Bratislava, and Faculty of Medicine, Comenius University, Bratislava, Slovakia

**Address for correspondence:** A. Thurzo, MD, Wolkrova 33, SK-851 01 Bratislava, Slovakia. Phone: +421.903.110107

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sons that are evaluated and voted up and down by people who love lesson design, curriculum and pedagogy.

*"The best person to do a job is the one who most wants to do that job; and the best people to evaluate their performance are their friends and peers who, by the way, will enthusiastically pitch in to improve the final product, simply for the sheer pleasure of helping one another and creating something beautiful from which they will all benefit"* (Jeff Howe, Crowdsourcing),

People want to participate and to collaborate on important projects. What could be more important than making our education system the best it could be? How many retired teachers, educators, and other professionals would still like to contribute? How many people love education, have valuable skills and expertise, but work in fields outside of education? The "crowd" doesn't care who you are, what you do, where you went to school, if you went to school, or what your expertise is. All that matters is you have something to contribute. Let the "crowd" have a go. Web-based communities, social networking, the transition of websites from mere information pages to real software applications and the expansion in broadband access have all been important factors in this "WEB 2.0". Is the dental education able to keep up with this change? (3) What would this mean for teaching and learning?

**Crowdsourcing and Web 2.0**

Web 2.0 is here. This term is describing changing trends in the use of World Wide Web technology. Trends that enhance the creativity, secure information sharing, collaboration and functionality of the web. Web 2.0 could be understood as another step in the evolution of web-based communities, including academic communities, and their functions and services. We meet new generations of students, grown on "Facebook" or other social-networking sites. We teach dental students who gained their "web literacy" long time before entering the college. Students familiarized with video sharing sites, wikis and blogs. The term "Web 2.0" does not refer to the update to any technical specifications, but to changes in the ways people utilize the Web. E-learning technologies in education use the adult learning theories that view the educator as a facilitator of learning and an assessor of outcomes. The change in the technology requires a shift in the focus of a course from the educator to the subject (4).

**Our online e-learning system**

Since October 2003, the e-learning project known as "BSM ON-LINE", supported by the Board of Vice Deans of Medical faculty Comenius University, has been launched at www.bsm.sk. The system itself and also the implementation of supporting features like ISIC identification has been presented on the Mefanet (MEdical FAculties Educational NETwork) conference in 2008 and later published (24, 25, 26). It was formerly concentrated on students of dentistry and soon attracted the interest of other medical students and due to an unexpected popularity it quickly continued in its further evolution (5). Soon it was transformed from the e-learning tool to a global academic-networking site offering many services. Under the students' pressure the system continuously updates its e-content and the web-technologies. The users can use any browser to access its resources and do not have to install any complementary software. At the beginning this web system started on php4, mysql4, html and the core was a primitive Content Management System (CMS). At the present time it is running on php5, mysql5, xhtml, xml and Ajax (asynchronous JavaScript and XML). Ajax is a group of web development techniques used for creating interactive web applications. With Ajax, web applications (*like our web system*) can retrieve data from the server asynchronously in the background without interfering with the display and behavior of the existing page. Web 2.0 requires simplicity of use as well as integration with modern web technologies (8).

In 2005, the web system gained the confidence and technical support of the Comenius University that allowed official web-identification of students and teachers based on the non-contact microchip cards (ISIC/ITIC). This was the crucial point to implement the official agenda like content personalization and PHP modules like on-line multiple-choice testing or official communication. Since the beginning, the main idea of our web system was the concept of "interactive participation platform", creating the "participatory web". The official web pages of our Medical faculty are in contrast to this participatory-web-concept. Despite they are built on new technology with WEB 2.0 capabilities, they still preserve the old concept. This older concept understood the educational web as the on-line information resource.

An interesting feature of our web system is the way of involvement of the dental students in the process of creating its content. The system is designed in the way that educates students along as they create the e-content and find it entertaining. Moreover the system architecture is adapted to current change of educational paradigm from teacher-centered model to student-centered model. This means that the system is not build arduously by teachers who create content and keep it updated. Their role is mostly rectifying and filtering the content. However they contribute with the high-quality data, presentations, lectures, articles or opinions in the debates and their function changed from teacher-centered scheme to rather supervising and complement to students "production". Students are able to gather data from all over the world and by that means they form on-line compilations of contemporary thematic content to any particular topic using only internet resources. As they do this, they learn. If we focus on processes of creating on-line exam questions and multiple choices, e-documents content, articles, policy papers, student reports from foreign clerkships or on-line forum texts, all are just supervised by teachers. The quality of such e-content materials must have well defined learning objectives and involve peer review to ensure its validity, accuracy, currency, the use of evidence-based data and the use of best practices. Using an easily accessible online data like pictures requires an attention of authorities to the copyright. It must be ensured not only that the developers' intellectual rights are protected but also that the original content needs to be secure from unauthorized changes. In the

area of assessment, traditional examination schemes can be enriched by IT, whilst the Internet can provide many innovative approaches. Future trends in IT will evolve around an improved uptake and access facilitated by the technology (hardware and software). The use of Web 2.0 shows a considerable promise and this may have implications on a global level (7). There is an increasing interest in the exciting possibilities of using social software for undergraduate medical education. Medical educators need to recognize the potential of social software in the undergraduate education but it is essential that students maintain the informality and privacy of these sites. The challenge for all medical educators is how to integrate social software into current curricula and institutional Virtual Learning Environments (VLEs) (8).

**Use of the system**

For example, the student can get the task from its tutor to create 10 pre-questions about the orthodontic early treatment for the on-line test. Student will logon in our web system and create 10 pre-questions. Of course this is not possible without studying the particular topic and after submitting the questions the teacher verifies these pre-questions. He rejects some, changes some if necessary and authorizes into the system depending on the criteria. All is done on-line and allows filtering the low quality questions or adding supplementary metadata. Also it allows creating huge sets of test questions that are ineffective to memorize and force students to study from literature. Situation when student creates test questions for other colleagues not only requires a good knowledge of the topic but also allows formulations that are easy to understand. Web-based lecture series results in an significantly increased examination performance (9). Sometime they act as teachers in relation to their younger colleagues, or communicate with older students and often get simplified but correct explanations. On-line "flames" in discussion forums on various topics in dentistry, links on new findings, interesting researches, clinical controversies, informative web animations and many other features reassembling a "small dental Wikipedia". At the current time the "crowd" acting on the web system cannot be clearly defined. Such contribution of students' to the e-content of the system fulfills the crowdsourcing principles. Crowdsourcing is a relatively recent word that has not been accepted into a mainstream language yet. It is described as an act of taking a task traditionally performed by an employee, and outsourcing it to a wide and not clearly defined group. The mass collaboration has been enabled by already mentioned WEB 2.0 technologies.

**WEB 2.0 in dental education**

Regarding the stream of dental e-education, the crowd is in our case represented by dental students from different parts of the country and different levels of education, some general medicine students, and high school students interested to study dentistry, young teachers, some senior lecturers and some laics. Surely not all of them have the same system rights and roles. But they create a community and the web system is an accessible place where everybody has a chance and way to contribute. The influence on particular parts of the crowd on the content varies from feature to feature. However the crowd brings the questions and also the answers. The crowd brings a lot of ballast that could be rectified and release interesting information of high value, the crowd brings ideas, some of which could be very precious. If the mechanism of control is working, the results will be better than from a limited group of professionals. This principle created many famous and successful crowdsourcing projects like YouTube, Facebook, Flickr or Wikipedia. The academic-networks could utilize this mechanism analogically to quote of Linus Pauling – "*The best way* to a *good idea is* to have *lots of* ideas."

**E-learning paradigm shift?**

The term WEB 2.0 brought the term "e-Learning 2.0". It is used to refer to new ways of thinking about the e-learning. From the e-Learning 2.0 perspective, conventional e-learning systems were based on the instructional packets that were delivered to students using Internet technologies. The role of the student was learning from the electronic documents, often PDFs or PowerPoint presentations (*rather passive*). In contrast, the new e-learning places increases emphasis on community learning and use of blogs, wikis, podcasts and virtual worlds such as Second life.

The first decade of e-learning (e-learning 1.0) was focused on using the internet to replicate the teacher-led experience. Content was designed to lead a learner through the content, providing a wide set of interactions, experiences, assessments, and simulations. E-learning 2.0, by contrast (patterned after Web 2.0) is built around collaboration. E-learning 2.0 assumes that knowledge (as meaning and understanding) is constructed socially. Learning takes place through conversations about content. Advocates of social learning claim that one of the best ways to learn something is to teach it to others. There is also an increased use of virtual classrooms (online presentations delivered live).

To understand how the WEB 2.0 e-learning influences the dental education, the retrospective analysis of students behavior in the web-learning environment has been atudied the last 4 years. To enlighten the current trends in the web 2.0 environment, an anonymous on-line questionnaire was evaluated every November for the last 5 years.

As mentioned during recent years, we have witnessed a new revolution in the field of communication through Internet Web 2.0, whose contents are provided by the collaboration, discussion, and sharing between users. Following the example of Wikipedia, medical wikis and blogs are being developed to support the medical education, the collaboration among researchers, and the clinical practice. However, these tools present some limitations related to their openness and ease of use which virtually allows anybody to alter and edit existing contents or to create new ones. This could make the contents unreliable and inaccurate, and could introduce risks for a correct medical education and for the health of those patients deciding to follow the medi-

**Table 1. - The retrospective analysis of students' behavior in the on/line e-learning environment.**

**The general overview**

| | *2005* | **2006** | **2007** | **2008** |
|---|---|---|---|---|
| New dental students' registrations | *8* | *13* | *27* | 53 |
| Average students' log-ins per month | *5,5* | 9,2 | 13,3 | 15,9 |
| Frequency of posting into discussion forums – 1 student per month | *2,5* | 2,5 | 2,8 | 3,3 |
| The average active on-line time per 1 student per month [minutes] | *42,4* | 44,8 | 189,8 | 323,0 |
| Annual increment of new registrations of dental students as the percentage of all dental students at the university | *x* | 2,5% | 7,0% | 13,0% |

**The group of 11 dental students**

| | **2006** | **2007** | **2008** |
|---|---|---|---|
| Average students' log-ins per month | *10,4* | *14,4* | *22,1* |
| Submissions of posts into forums – 1 student per month | 3,0 | 3,1 | 2,4 |
| Average active on-line time 1 user/month [minutes] | 65,3 | 299,8 | 997,3 |

cal advice included. This limitation is avoided in the supervised semi-open systems like our web-system onwww.bsm.sk. There are still many studies necessary to evaluate limits, benefits, and efficacy of these tools when used in the contexts of medical education and clinical practice. Other studies are needed to evaluate the reliability and the accuracy of the medical contents posted online through the web 2.0 services (13).

Web 2.0 include social networking services, instant messaging, chatting, collaborative filtering, social bookmarking, social search engines, file sharing and tagging. The popular Web 2.0 applications in education, namely wikis, blogs and podcasts, are the tip of the social software iceberg. Web 2.0 technologies represent a quite revolutionary way of managing and repurposing/ /remixing online information and knowledge repositories, including clinical and research information, in comparison with the traditional Web 1.0 model. (14)

## Methods

A retrospective analysis, on-line questionnaire and randomized double-blind parallel study were designed to evaluate the current trends in e-learning and study its effect on students' knowledge quality and retention. The retrospective analysis and on-line questionnaire were aimed on the on-line e-learning platform and the parallel study was evaluating the impact of the offline e-learning on the long-term knowledge retention.

The retrospective analysis was realized on the web system LOG. Web system LOG has been recording all system events since the beginning in 2003. The retrospective analysis consists of two parts. First part is a general overview of students' behavior in the e-learning system (Tab. 1). The second part is the overview of evolution of specific group actions in the system over 4 years. Only data from November 2005 until November 2008 were taken into account and the data for the year 2005 are in gray because the reliable identification of students by the university has been implemented during the year 2005. From all data only the data of new users' registrations, users' log-ins, submissions of posts into forums and the active on-line times were extracted. Active on-line time was defined as time between login and the last recorded user action – event in that session. This was to avoid counting with invaluable data when user logged on and remained inactive in the system until system automatically logged him off. The auto log-off time was adjustable by user.

In the *general overview,* the following data was estimated:

1) The annual increment of new registrations of dental students in the system. It was put in correlation with the total sum of dental students in the university (200) and calculated for years 2006, 2007 and 2008.

2) The average number of user log-ins per month was evaluated per years 2006, 2007 and 2008. Only one login per day was counted, so the maximum in 30 days was 30 logins.

3) General on-line time spent by 1 user per month was evaluated for years 2006, 2007 and 2008.

4) The number of submissions in the discussion forums per month for years 2006–2008.

In studying the trends in the web 2.0 e-learning, the on-line behavior change of the known group of dental students was analyzed. While the limiting factor was that user must be active in the system for each year from 2006 till 2008, only 11 students fully met these criteria. For those students, the same indicators as in the general overview were estimated, except for new users' registrations.

The anonymous on-line questionnaire was evaluated annually each November from 2004 till 2008 (*five years*). The researched topic was the average number and type of resources used for study/exam preparation for dental subjects during the exam period. The questionnaire was integrated in the web-portal and run on freeware script "Advanced Poll". Currently the version 2.08 is used. This script is free for academic use and allows a good control of anonymous submissions blocking repeated submissions. To answer the questionnaire it was not necessary to log-on in the web system and each November was the questionnaire set to zero.

**Table 2. - The question of anonymous on-line questionnaire was: "In preparation for dental subjects during exam period, you study mostly from (sources):"**

| | Annual increment in % | | | | Average annual increment | % distribution of all respondents | |
|---|---|---|---|---|---|---|---|
| | *2005* | *2006* | *2007* | *2008* | | *2008* | *2004* |
| **only paper data - books, notes** usually less than 3 per exam in average | 140,0 | 16,7 | -14,3 | 8,3 | 37,7 | 6,4 | 26,3 |
| **only paper data - books, notes** usually 3 and more per exam in average | -33,3 | 100,0 | 75,0 | -14,3 | 31,8 | 3,0 | 15,8 |
| **paper data sometimes combined with Internet**, together less than 3 sources in average | 100,0 | 187,5 | 8,7 | 0,0 | 74,0 | 12,4 | 21,1 |
| **paper data sometimes combined with Internet**, together 3 and more sources per exam in average | 50,0 | 166,7 | 87,5 | 53,3 | 89,4 | 11,4 | 10,5 |
| **paper data always combined with Internet**, together less than 3 sources in average | 66,7 | 340,0 | 81,8 | 20,0 | **127,1** | 23,8 | 15,8 |
| **paper data always combined with Internet**, together 3 and more sources per exam in average | 100,0 | 200,0 | 433,3 | 56,3 | **197,4** | 24,8 | 5,3 |
| **Internet combined with paper resources**, together less than 3 sources in average | 200,0 | 33,3 | 50,0 | 33,3 | 79,2 | 4,0 | 5,3 |
| **Internet combined with paper resources**, together 3 and more sources per exam in average | 0,0 | 125,0 | 155,6 | 26,1 | 76,7 | 14,4 | 0,0 |
| **only Internet** (*zero for all years*) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

The questionnaire was multiple-choice-type where only one option could be selected and could be submitted only once in the 12 month monitoring period. It was used to research the trends regarding the average number and type of resources used for exam preparation during exam period. Only data for dental students were extracted.

The headline was "*In preparation for dental subjects during exam period, you study mostly from:*". Answers and results in Table 2. In the same table the following aspects were calculated according to the questionnaire output:

– The annual increase (%) for each option and each year.

– The average annual increase.

– The distribution of the sources used for exam preparation today and 5 years ago.

The randomized double-blind parallel study was intended to study the impact of the off-line e-learning on the long-term retention of knowledge regarding cephalometric analysis in orthodontics. Collected data were analyzed by the unpaired student's t-test. 24 dental students were randomly assigned into two equal groups. The study compares knowledge of particular cephalometric parameters in the three consecutive years in the same students. Students were educated in their 4th grade and examined in the same year and 5th and 6th grade (*3 times in total*).

The first group learned and practiced the digital cephalometric analysis in the Dolphin imaging software version 10 using digital cephalogram. The second group learned and practiced the manual cephalometric analysis on the analog cephalogram. Both groups were educated for the same amount of time – 2 consecutive lessons at the department of orthodontics in the 4th grade. During examination, students were asked to define and identify 10 cephalometric parameters on the same cephalogram randomly chosen every year. The parameters were the following: *Sella, Nasion, B point, Pogonion, Menton, ANB angle, Occlusal plane, Interincisal angle, Wits appraisal, Palatal-mandibular angle*). Students received from 0 to 10 points for correct answers. The comparison of results of both groups was evaluated by the student's T-test (*Two-Sample Assuming Equal Variances*) for each year. 2006 – 4th grade, 2007 – 5th grade and 2008 – 6th grade.

To prove that one method of education is significantly better was not enough to compare the total scores of the two groups for each year (Tab. 1) but to prove that means of the methods are significantly different. Our null hypothesis was that the means of both groups' scores are not significantly different from each other. This would indicate that both educational methods are equal. Ho (M1=M2) where M1 is mean of scores of e-learning and M2 mean of scores of manual method in the same year. The alternative hypothesis was that one of the methods is significantly better H1 (M2–M1>0). We have chosen two values for • (levels of threshold for statistical significance) 0.05 and 0.01 at which we tested the null hypothesis in each year. If the calculated p (T•t) one-tail value lies below the threshold level, then the null hypothesis that stated that the two methods do not differ

**Table 3. T-Test (Two-Sample Assuming Equal Variances) comparing the examination scores of two student groups in years 2006, 2007 and 2008.**

| | **4th grade (2006)** | | **5th grade (2007)** | | **6th grade (2008)** | |
|---|---|---|---|---|---|---|
| | ***e-learning*** | ***manual*** | ***e-learning*** | ***manual*** | ***e-learning*** | ***manual*** |
| Examination – summary score | *99/120* | *88/120* | *92/120* | *72/120* | *99/120* | *73/120* |
| Mean | 8,2500 | 7,3333 | 7,6667 | 6,0000 | 8,2500 | 6,0833 |
| Variance | 1,4773 | 1,6970 | 0,7879 | 0,5455 | 1,6591 | 0,6288 |
| Number of observations | 12 | 12 | 12 | 12 | 12 | 12 |
| Pooled Variance | 1,5871 | | 0,6667 | | 1,1439 | |
| Hypothesized Mean Difference | 0 | | 0 | | 0 | |
| Df | 22 | | 22 | | 22 | |
| t Stat | 1,7823 | | 5,0000 | | 4,9621 | |
| P(T<=t) one-tail | **0,0442538** | | **0,0000263** | | **0,0000289** | |
| P < α (α = 0,01) | **NOT SIGNIFICANT** | | SIGNIFICANT | | SIGNIFICANT | |
| P < α (α = 0,05) | SIGNIFICANT | | SIGNIFICANT | | SIGNIFICANT | |

is rejected in favor of an alternative hypothesis, which stated that the groups do significantly differ. While there was just one educational impulse for the students in the 4th grade in the evaluated topic, • has been calculated and compared in three consecutive years to estimate the strength of annual growing difference of scores. Based on the results, the effect of e-learning on the long-term retention of knowledge could be estimated. The students of both groups had the same educational conditions and environment. During 5th grade there is a light decrement in the scores due to curriculum with more emphasize on other subject and on the contrary in the 6th grade an increase due to closing state exams from dental subjects.

**Results**

The results of the retrospective analysis (Tab. 1) are divided into two parts. The upper part describes a general overview of the trends of all dental students. The lower part describes only the group of the same eleven students.

In the general overview of the retrospective LOG analysis, there is an obvious increase of all researched parameters. The sum of the dental students studying at the Comenius University was approximately 200 in 2008 with a plan to increase the number to 250 within next 2 years (*including foreign students*). The percentage of the "newcomers" to the system doubles every year and more than 90% of already registered students prolong their registration every year. Keeping this trend, the system will cover more than 90 % of the dental student community within next two years. The participation is on the voluntary basis. An interesting observation in this global overview is a rapid increase of the active on-line time spent in the system after the year 2006. In this year, 40 GB the e-content has been uploaded, that tripled the former volume of the on-line content and also an interactive on-line testing module has been launched. The average students' log-ins per month was not increasing as rapidly as expected and this is due to the trend of newcomers being rather passive for the first months. High numbers of newcomers reduce the overall parameter of logins per month.

From the behavior analysis of the group of dental students, the results showed a wide difference from the same parameters in the general overview. The average students' log-ins per month evaluated for 2008 was highly above the average for the same year in the global analysis. This was in contrast to the decrease of frequency of posting on the forums. This is an interesting feature that indicates that despite the old users increase the regularity of their logins they less contribute to the discussions. Their average on-line time is extreme in comparison to the average trend in the community.

The results of on-line questionnaire in the (Tab. 2) are divided into three main parts. The first part is the annual percentage increment for the years 2005–2008 and reveals the trends in the usage of various resources in exam preparation. There is an obvious reduction of the group revising only paper resources in the first two rows. The numbers in the first evaluation (2005) are too variable due to the fact that only 19 students participated in the questionnaire in the previous year (2004). The participation of the students was following: 2005 – 39 students, 2006 – 90 students, 2007 – 160 students and 2008 – 202 students. The questionnaire has totally 510 respondents – dental students.

The second part of the table describes the annual average increment with currently leading rows 5 and 6 scoring, especially the last two years. This signifies the change of typical exam preparation from recommended 1–3 pieces of hardcover literature to „multi-sourcing" way with an intensive use of Internet. So far nobody uses only the Internet for the exam preparation.

The last – third part of the table is the comparison of the years 2008 and 2004 together. They represent the distribution (%) of respondents between all categories. In the year 2004 there was more than 40 % of the students preparing from paper data without the help of Internet, in 2008 it was less than 10 %. The trend is clearly the increasing use of more resources per one subject than in the past and a significant supply of these resources mainly from the internet.

The results of the randomized double-blind parallel study in the Table 3 show two interesting properties. Firstly, comparing the scores of e-learning method of cephalometric analysis and

**Fig. 1. Example of manual method of cephalometric analysis (left) and digital method (right).**

conventional manual method immediately in the first year (2006), there was a significant difference only at the level $\alpha = 0.05$ however not at $\alpha = 0.01$. This indicates that the skill of both groups is comparable and despite the e-learned group shows better results they are significantly better only with $\alpha = 0.05$. As the time passes, both groups were tested in their 5th and 6th grade and their scores decreases at different speeds and start to differ very significantly. The official education of this particular topic was done only in the 4th grade and was not repeated. Relatively better results in the last year (2008) are caused by students' autonomous revising for the final exams in the 6th grade. The results confirm a better retention of knowledge acquired by e-learning (Fig. 1).

## Discussion

The new and important aspect of this research is the verdict resulting from research that WEB 2.0 technologies not only make the e-learning on the web more effective but also shift the paradigm of web education from informative to creative platform. This is easy to utilize in the dental education as proved by our experience with the described web-system. The research confirmed expected trends in students' fast adaptability to a new educational tool. Increasing volunteer subscriptions of dental students to the web-portal are driven not only by a desire to gather new information by more interesting way but with a new source of attractiveness – the aspect of social networking. This phenomenon mustn't be ignored.

The important aspect of the study is the conclusion that offline e-learning has a significantly positive impact on the retention of knowledge. The long-term retention of knowledge was better in students who learned digital cephalometric analysis and this might be the result of more amusing way of education rather than specific technological impact.

Other findings exploring the on-line trends and behaviors of dental students are in correlation to Wesch (20) and other tendencies.

Enhancements to e-learning portals have a significant effect on the way the students study and this effect must be respected when planning further innovations in dental education. The crowdsourcing mechanism works well in many different areas of cyberspace and can be also utilized in academic education. However the collaborators rule: „the wisdom of the group often replaces the expert" does not always apply to academic environment. Not only the results – the e-content (*on-line courses, tests, presentations or reports*) are important in use of web 2.0 crowdsourcing mechanisms. The process leading to results is also important. The "crowdsourcing" way of creating that e-content shouldn't be overlooked because during creating the on-line content the students learn.

The educational content is getting more mobile and available. Students' requirements on freshness, accuracy and comprehensibility of educational information are increasing. The web has already changed from place to gather information to place of creation of information. The contrast between informative web and creative web implies the future development of educational web tools. They will not remain a side stream or an alternative tool, but they will become the central platform for learning and creating.

Implications of the findings of this study for future research and clinical practice are clear. The emerging community aspect will form the pressure to move other academic processes online. The web-interactivity will increase and the e-learning will advance. Other studies to research the impact of e-learning on the skills of the students are desirable. Currently all students are taught the cephalometric analysis in the digital environment.

## Limitations

The limitation of our study is a relatively small size of groups in the parallel study. This was due to the fact that not all dental students remained in the system continuously for all years. Another limitation is the anonymity of the on-line questionnaire. This prevents us from the confidence that only dental students participated in the questionnaire. This questionnaire could have been posted from two different computers (*different IP and MAC address*) by the same person.

## Conclusions

The use of web 2.0-based education has a rapidly increasing trend and currently the students increase the number of sources they use for learning taking advantage especially from the vast internet resources.

The e-learning method of cephalometric analysis showed to be more efficient in comparison to the conventional during an immediate testing after the lecture. However the more important is the effect on the retention of the students' knowledge that was remarkably better after 12 and 24 months in the group educated by e-learning.

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