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Research Article

From subjective self-assessment to objective behavior – use and acceptance of a web 2.0 based e-learning structure in infection control

Von der subjektiven Einschätzung zum objektiven Verhalten – Nutzung und Akzeptanz einer Web 2.0-basierten E-Learning-Struktur in Hygieneweiterbildungen

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Abstract

Background: E-learning in nursing continuing education is an effective and increasingly used tool. Web 2.0 e-learning approaches hold potential to positively impact obtained knowledge, thus improving overall healthcare related outcomes. Perceived computer user self-efficacy is an indicator for using a computer and thus is the basis of using a web 2.0 e-learning structure.

Objectives: Objectives for this study were (1) to describe participants' use and acceptance of the web 2.0 e-learning system, and (2) to explain relationships between the computer user self-efficacy as an indicator for objective behavior in an online environment and the use of the e-learning system.

Methods: A quantitative assessment of the usage of a web 2.0 e-learning environment, accompanying a traditional classroom-based face-to-face training, was conducted. Participants were highly qualified infection control nurses and variables tested were: *perceived computer user self-efficacy, total interaction time with the e-learning system, total number of actions performed in the system, total number of sessions without any action, total number of sessions with at least one action, total online time around face-to-face training* and *total online time without face-to-face training.*

Results: Significant differences occurred between *total online time around face-to-face training* and *total online time without face-to-face training* ($Z=-3.73$, $p<.000$). No differences were seen between *sessions without any action* and *sessions with at least one action* ($Z=-0.73$, $p=.465$). The Results indicated no correlation between *computer user self-efficacy scale scores* and *total number of actions performed in the system* ($r=.12$, $p=.151$). However, there were significant positive correlations between *total interaction time with the e-learning system* and *total number of actions performed in the system* ($r=.47$, $p<.000$) and *computer user self-efficacy scale scores* and *the total interaction time with the e-learning system* ($r=.17$, $p<.042$).

Discussion: Participants actively used the web 2.0 e-learning structure. Significantly more online time around face-to-face trainings leads to the cautious conclusion that moderation of the e-learning structure may be crucial for the overall usage time. A high-perceived computer user self-efficacy may be an indicator for overall usage time of the web 2.0 e-learning paradigm.

Keywords: web 2.0, hygiene, curriculum, e-learning, perceived computer user self-efficacy

Zusammenfassung

Hintergrund: E-Learning ist ein effektives Instrument und wird zunehmend in der Fort- und Weiterbildung auch von Pflegenden eingesetzt. Dabei ist E-Learning in der Lage Lernerfolge zu verbessern. Web 2.0-basierte E-Learning-Strukturen haben Potential zur Verbesserung des Lernerfolges, weshalb ihr Einsatz zunehmend gefordert wird. Ein positiver Lernerfolg ist im Bereich der Pflege von großer Bedeutung, da dieser mit einem verbesserten Patienten-Outcome in Verbindung steht. Als Voraussetzung zur Nutzung von Web 2.0-basierten E-Learning-Strukturen kann die subjektive erwartete computerbezogene Selbstwirksamkeitserwartung herangezogen werden.
Fragestellung: Die Fragestellungen der vorliegenden Studie sind zum einen, ob die Teilnehmenden das E-Learning-System genutzt und akzeptiert haben und zum anderen, ob die subjektive Einschätzung der computerbezogenen Selbstwirksamkeit ein Indikator für objektives Verhalten in der virtuellen Lernumgebung darstellt.
Methode: Quantitative Erhebung der Nutzung einer Web 2.0-basierten E-Learning-Struktur parallel zu einem Präsenzweiterbildungscurriculum. Die Teilnehmenden waren hochspezialisierte Hygienefachkräfte. Die zu untersuchenden Variablen waren: *subjektiv eingeschätzte computerbezogene Selbstwirksamkeitserwartung, gesamte Interaktionszeit mit dem E-Learning-System, Gesamtzahl der Interaktionen welche im System durchgeführt wurden, Gesamtzahl der Sessions ohne jegliche Aktion, Gesamtzahl der Sessions mit mindestens einer Aktion, gesamte Online-Zeit in Nähe zu Präsenztagen* und *gesamte Online-Zeit ohne Nähe zu Präsenztagen.*
Ergebnisse: Die Ergebnisse zeigen signifikante Unterschiede zwischen der *gesamten Online-Zeit in Nähe zu Präsenztagen* und der *gesamten Online-Zeit ohne Nähe zu Präsenztagen* ($Z=-3.73$, $p<.000$). Es gibt keine Unterschiede zwischen der *Gesamtzahl der Sessions ohne jegliche Aktion* und der *Gesamtzahl der Sessions mit mindestens einer Aktion* ($Z=-0.73$, $p=.465$). Die Ergebnisse zeigen keine signifikante Korrelation zwischen der *subjektiv eingeschätzten computerbezogenen Selbstwirksamkeitserwartung* und der *Gesamtzahl der Interaktionen welche im System durchgeführt wurden* ($r=.12$, $p=.151$). Aber es gab signifikante Korrelationen zwischen der *gesamten Interaktionszeit mit dem E-Learning-System* und der *Gesamtzahl der Interaktionen welche im System durchgeführt wurden* ($r=.47$, $p<.000$) und zwischen der *subjektiv eingeschätzten computerbezogenen Selbstwirksamkeitserwartung* und der *gesamten Interaktionszeit mit dem E-Learning-System* ($r=.17$, $p<.042$).
Diskussion: Die Teilnehmenden haben die Web 2.0-E-Learning-Struktur aktiv genutzt. Eine signifikant höhere online Zeit um die Präsenstage lässt den vorsichtigen Schluss zu, dass eine Moderation der Interaktion der Teilnehmenden von großer Bedeutung ist. Eine hohe subjektiv eingeschätzte computerbezogene Selbstwirksamkeitserwartung scheint in Indikator für die Gesamtnutzungszeit in einer Web 2.0-basierten E-Learning-Struktur zu sein.

Schlüsselwörter: Web 2.0, Hygiene, Curriculum, E-Learning, computerbezogene Selbstwirksamkeitserwartung

Background

According to Ebner e-learning, or e-learning 1.0, can be described as the extension of classical education [1]. Existing teaching forms were enhanced with media; and online systems were only used as content management systems [1]. Due to technological advancements, web 2.0 e-learning is advantageous for learning processes due to online social interaction [2], [3]. Web 2.0 can be described as a more dynamic version of web 1.0, as social online interaction is a major focus [4]. More specifically, web 1.0 connects participants with the internet, whereas web 2.0 connects course participants with other individuals, thus e-learning 2.0 results in a more collaborative and social way of learning [4]. Within the past years, e-learning has increasingly been used in nursing continuing education [5], [6], [7], [8]. A recent systematic review states that e-learning in nursing continuing education is not less effective with respect to an increase of knowledge and skills when compared to traditional learning methods [9]. In particular, a web 2.0 e-learning approach is highlighted in nursing continuing education, with social interaction through connecting participants through the internet being a key element [10].

E-learning in infection prevention has been shown to positively impact learning outcomes [6], thus being an effective educational tool for continuing education in healthcare [10]. Continuing education is crucial within this sector in order to improve healthcare related outcomes [11], [12]. Additionally, it may be seen as a preventive strategy to decrease the yearly 4.1 million patients affected by infections during their hospital stay (health care associated infections) which account for approximately 37,000 deaths [13]. These infections result in 16 million more days stayed in hospitals, causing an extra cost of 7 Billion Euros/year in the European Union [13]. Statistics in Germany suggest that approximately half a million patients suffer from infections acquired during their hospital stay every year [14]. Taking these data and a new legislative guideline in Germany into consideration, the authors developed a curriculum to improve infection control [15]. The face-to-face elements of the curriculum were designed to educate infection control nurses to perform better training courses for infection control link nurses, using the 'train the trainer approach' [16], [17]. Infection control nurses were educated within the field of psychology, including social psychology to understand dynamic group processes, focusing on social interactions [18]. As a supplement to the curriculum, a web 2.0 e-learning structure was established to facilitate potential learning outcomes, facing the problem of health care associated infections [6], [10], [13]. The described curriculum was evaluated using a multi-level study design including quantitative and qualitative methods [16], [17], [18], [19].

Perceived self-efficacy is one of the first steps leading to specific social behavior [20], [21]. Perceived self-efficacy is a construct of the social cognitive theory of Bandura, which is one of the most prominent theories to describe human behavior [20], [21]. Perceived self-efficacy is described as an individual's belief that his or her behavior leads to a desired goal or achievement [20], [21]. With respect to a specific online environment, Cassidy and Eachus describe the computer user self-efficacy as an important factor for the effective usage of a computer in a learning context, therefore being the basis for online interaction [22]. As a result, missing computer user self-efficacy may be a possible inhibitor of social interaction within a web 2.0 e-leaning environment.

In a previous study, the initial acceptance regarding a web 2.0 e-learning structure was descriptively analysed [23]. Main findings suggest that the participants sufficiently used the new web 2.0 e-learning structure within the first six months and that the interaction based web 2.0 e-learning approach may be a useful resource within a curriculum structure to improve infection control. No in-depth analyses about the way of using the e-learning structure or possible predictors that influence the usage of the e-learning structure were performed [23].

Taking the importance of learning and the potential of web 2.0 e-learning structures to facilitate learning in nursing continuing education into consideration, the aims of this study were

1. to describe participants' use and acceptance of the web 2.0 e-learning system, and
2. to explain relationships between the computer user self-efficacy as an indicator for objective behavior in an online environment and the use of the e-learning system.

Methods

Design

This report focuses on the quantitative evaluation of the web 2.0 e-learning structure within this curriculum. To assess the importance of social interaction and the possibilities of the web 2.0, a web 2.0 e-learning structure using a virtual private social network was established in addition to the traditional classroom training. The e-learning study group used an Elgg© based social networking software to implement the e-learning environment. Traditional classroom-based sessions were offered as face-to-face trainings. For participants in a classroom group e-learning environments were programmed which enabled them to expand their interactions to online discussions between the face-to-face training sessions. This study has a positive ethics recommendation for implementation. It was approved by the institutional review board of the investigators institution.

Participants

The participants had a qualification as nurse and a further qualification as infection control nurse in Germany. Participants were recruited nationwide through gatekeepers

in Cologne, Frankfurt, Berlin, Witten, and Dortmund. Flyers were distributed to reach out the population of interest. Additionally, a homepage was created for advertising purposes. Being part of a multi-level evaluation as described in the background, the sample size of this pilot-study was predefined by the overall number participants, who participated in the e-learning structure.

Data collection

Data collection took place between 2014 and 2016. The curriculum had a modular structure including four classroom-based face-to-face training days. After the first face-to-face training, the participants were included in the web 2.0 private social network to interact within their cohort. The face-to-face training days were followed by a four week cool down period between training days 1–3, and at least 3 months between training days three and four. Prior to the first usage of the e-learning structure, participants were asked to fill out a questionnaire to assess their perceived computer user self-efficacy. The assessment of the usage of the e-learning structure took place via a database image file over three years.

Questionnaire to assess the perceived computer user self-efficacy

To assess the participants' perceived computer user self-efficacy, the German validated version of the computer user self-efficacy scale was used [22], [24]. The computer user self-efficacy scale is a 30-item scale resulting in one sum score.
The overall score is calculated as sum of all item scores with potential total score ranges between 30 and 180. The items can be rated on a six point Likert-scale with preferred or non-preferred statements. Higher total scores indicate better perceived computer user self-efficacy.

Procedure to assess information from the database image file

Due to the high complexity of the database image file, it was necessary to create an algorithm to assess relevant information for this study. Based on that algorithm, all users of the user table were loaded. This was followed by loading all data of the log table and assigned to the respective users. At this point the log entries were not processed. Now the algorithm iterates over the users and excluded all, which could not be assigned to a log entry. In a next step, the algorithm excluded all users that did not have an action *login*, as without the login data it was impossible to calculate a session length. The log entries for each individual user were then divided into sessions. Sessions can be described as regular and special cases, which are described in the Appendix.
After the algorithm created the sessions it aggregated the actions within a session for every single individual. The events were aggregated into the actions *update, create, delete, annotate, login, logout*. The algorithm added the following attributes to each session: *total number of actions, total amount of time in minutes, total number of actions* broken down into *update, create, delete, annotate, login, logout*. In the final step, the algorithm added the following attributes to each user: *total amount of login time in minutes, shortest session in minutes, longest session in minutes, total amount of sessions without* a row of actions between the login action and the logout action, *total number of sessions with* at least one element in the row of actions between the login action and the logout action, *total number of sessions, average number of action* in a session. A session without an action between login action and logout action was equivalent to a participant using the e-learning structure for example, reading content.

Variables assessed from the database image file

The assessment of the usage of the e-learning structure took place via a database image file, which was extracted from the server. To describe the usage, variables were created from the database image file with the help of the described algorithm. These main variables were the *total interaction time with the e-learning system*, the *total number of actions performed in the system*, the *total number of sessions without any action* and the *total number of sessions with at least one action* performed.
To get more insight about the usage of the participants, sub-variables were computed. The online time within a range of plus/ minus days around a face-to-face training day was added, resulting in the variable *online time around face-to-face training*. Likewise, the online time within a range of plus/ minus days around the day that marks the largest distance between two face-to-face training days was added, resulting in the variable *online time without face-to-face training*. This biggest distance between two face-to-face training days was defined as two weeks after a face-to-face training day. This procedure was executed for the face-to-face training days two, three and four and their respective counterparts. The resulting values for the variables *online time around face-to-face training* and *online time without face-to-face training* were summed to the variables *total online time around face-to-face training* and *total online time without face-to-face training* for each participant.

Statistical analysis

All statistical analyses were based on the database image file and the computer user self-efficacy scale and were performed using IBM SPSS Statistics 22. Descriptive statistics were computed for sample characteristics and the usage of the web 2.0 e-learning structure as appropriate. The total values for the variables: *total interaction time with the e-learning system, total number of actions performed in the system, total number of sessions without any action, total number of sessions with at least one*

Table 1: Test for normal distribution. Significant test results indicate no normal distribution within this sample.

Variables	Kolmogorov-Smirnov test
Sessions without any action	Z=3.23, p<.000
Sessions with at least one action	Z=2.46, p<.000
Total online time around face-to-face training	Z=3.94, p<.000
Total online time without face-to-face training	Z=3.83, p<.000
Computer user self-efficacy scale scores	Z=0.83, p=.502
Total interaction time with the e-learning system	Z=3.27, p<.000
Total number of actions performed in the system	Z=1.61, p<.011

Table 2: Overview of the variables, describing the usage of the e-learning system

Variable	Overall	Mean per user
Total interaction time with the e-learning system	50,949 minutes	547.84 minutes
Total number of actions performed in the system	15,522 actions	166.90 actions
Sessions without any action	698 sessions	7.51 sessions
Sessions with at least one action	453 sessions	4.87 sessions
Total online time around face-to-face training	6,473 minutes	69.60 minutes
Total online time without face-to-face training	905 minutes	9.73 minutes

action, total online time around face-to-face training and *total online time without face-to-face training* were analysed using inferential statistics. For all analyses, only complete datasets were used. A two-sided α of .05 was determined a priori for all statistical analyses. For all statistical analyses, nonparametric Wilcoxon signed-rank tests were used as most of the variables were not normally distributed. To test for normal distribution the Kolmogorov-Smirnov test was performed. The Kolmogorov-Smirnov test indicated that *the computer user self-efficacy* was normally distributed; all other variables had no normal distributions. The distribution of variables is presented in Table 1. Kendall's Tau rank correlation procedures were used to test the correlation between the variables: computer user self-efficacy scale, total interaction time with the e-learning system and total number of actions performed in the system, because of its robustness in context of outliners and its statistical efficiency [25].

Results

Sample characteristics

Ninety-three participants (N=93) were part of the web 2.0 e-learning structure. Infection control nurses from 76 hospitals nationwide participated in this study. 85.6% were female, and 14.4% were male and most of the participants were older than 41 years (47.2% between 41–50 years; 35.2% older than 50 years). The majority of participants had professional experience extending 10 years (94.4%).

Perceived computer user self-efficacy

Within the participants of the e-learning structure, 67 participants filled in the questionnaire, corresponding to a 72% response rate. Participants' computer user self-efficacy overall sum scores, with a possible range of 30 to 180, had a mean value of *M*=135.22 (*SD*=20.54).

Usage of the e-learning system

Description of the usage of the e-learning system

Overall, participants spent a total online time of 50,949 minutes (=849.15 hours).The mean online time per user was *M*=547.84 minutes (*SD*=1323.05 minutes). They showed in total 15,522 actions over time, being a mean of *M*=166.90 actions (*SD*=164.26 actions) per user.
The total number of sessions without any action between a login action and a logout action was 698 sessions. The mean number of sessions without any action per user was *M*=7.51 sessions (*SD*=17.65 sessions). The total number of sessions with at least one action performed between a login action and a logout action was 453 sessions, with a mean number of sessions with at least one action per user being *M*=4.87 sessions (*SD*=6.32 sessions).
The total online time within a 3 day period around a face-to-face training day was 6,473 minutes, leading to a mean online time of *M*=69.60 minutes per user (*SD*=300.93 minutes) around face-to-face trainings. The total online time within a 3-day period around the day two weeks after the face-to-face training day was 905 minutes. The mean online time per user was *M*=9.73 minutes (*SD*=37.34 minutes) around the described time period after face-to-face trainings. Table 2 provides an overview of the variables describing the usage of the e-learning system.

Usage behavior within the e-learning system

There were significant differences between the variables *total online time around face-to-face training* and *total online time without face-to-face training* (Z=–3.73, p<.000). But there were no significant differences between the variables' *sessions without any action* and *sessions with at least one action* (Z=–0.73, p=.465). No significant correlation appeared between *computer user self-efficacy scale scores* and *total number of actions performed in the system* (r=.12, p=.151). There was a significant positive correlation between *total interaction time with the e-learning system* and *total number of actions performed in the system* (r=.47, p<.000). Furthermore, a significant positive correlation between the *computer user self-efficacy scale scores* and the *total interaction time with the e-learning system* was assessed (r=.17, p<.042).

Discussion

Participants accepted the web 2.0 e-learning structure and used the system nearly 850 hours, performing over 15,000 actions. A positive correlation between *computer user self-efficacy* and the *total interaction time with the e-learning system* leads to the cautious conclusion that subjective assessment may be an indicator for objective behavior in this online environment.

According to Ebner, e-learning 1.0 can be described as a content management system [1], such that learning is happening alone after downloading data. A web 2.0 based e-learning system can also be used in a similar way, resulting in participants' exclusively consuming content alone, not interacting with other individuals. Our findings demonstrate that there was no difference in occurrence between sessions with and without performed action, suggesting that the participants may have used the web 2.0 e-learning structure not only as passive recipients, but also as active users. Sessions without actions performed can be described as 'reading only' sessions, without any further interaction with the system.

Due to the pilot nature of this web 2.0 e-learning environment, the researchers did not intentionally moderate the e-learning system. Without any moderation as a confounding variable, the chance was increased to measure the real interaction time and performed actions of the participants with the system. However, findings demonstrate, that the usage of the system increased significantly in the 3-day interval before and after the face-to-face training days. As Donaldson and colleagues state, a strong instructor presence on the online environment is a key element for successful online learning [26]. Course moderation may be beneficial in further use of the web 2.0 e-learning system to motivate participants to interact with the system and thus to interact with other users.

The correlation between usage time and actions performed was very strong. This and the fact, that there was no significant difference between the number of sessions with no and with at least one action performed in the system, indicate the existence of few users who used the web 2.0 e-learning environment to a much greater extent than other users participating in this study.

There was a significant positive correlation between the perceived computer user self-efficacy and the total interaction time with the e-learning system. This may indicate that the perceived computer user self-efficacy is a useful indicator for the usage time within the web 2.0 e-learning environment. This means that the subjective feeling of self-efficacy may lead to more online time spent in the web 2.0 e-learning environment, reflecting an objective behavior. And within this online time, our findings suggest albeit with caution that the participants were more likely using the web 2.0 e-learning as active users, interacting with each other, than just consuming content. This conclusion is based on non-significant differences between sessions with or without any actions.

Related work

It has been shown that e-learning structures are being used in nursing continuing education [5], [6], [7], [8] alongside with web 2.0 approaches [10]. Keeping in mind that web 2.0 is based on online social interaction [2], [3] this article presents a potential way to facilitate online interaction time with web 2.0 e-learning structures in nursing continuing education.

In a recent study, Alley and colleagues discussed a relationship between internet self-efficacy and interaction time either with a web 1.0 based website or a web 2.0 based website. Their results indicate that higher internet self-efficacy is associated with more time spent on a website. This effect is significantly stronger for web 2.0 based websites compared to web 1.0 based ones and was assessed with older Australian adults (≥55 years). In contrast to the presented study, Alley and colleagues did not focus on e-learning systems [27]. The described findings are in concordance with the findings presented in this study. They demonstrate that higher perceived self-efficacy is positively associated with usage time of a website while focusing on other application areas of web 2.0.

Limitations

One limitation of this research is the analysis of the database image file itself. It is difficult to analyse the specific content of actions performed in an e-learning environment in detail. Welker and colleagues state that the content, for example, of the action *create or update* in the database image file cannot be completely analysed as the researcher cannot be sure what was exactly created or updated [28]. Analysis of a database image file provides useful information about the way an e-learning system is used, while it provides very limited information about the content created within the e-learning system.

The computer user self-efficacy scale resulted in a 72% response rate which is sufficient, however, it needs to be

improved to reduce the dropout of data when comparing the online behavior in the database image file with the computer user self-efficacy scale.
As a pilot project the given study was restricted in the number of participants.

Future research

In further research, higher numbers of potential interactions between participants enrolled should be encouraged. Computer user self-efficacy in participants in nursing continuing education can be assessed to tailor interventions to improve the potential use of web 2.0 e-learning structures. In addition, content analyses of the performed actions may be useful to obtain more detailed information about the content being created. Further research could assess, whether the system can be used without corresponding face-to-face training days, which had been part of the research presented.

Conclusion

As described in social cognitive theory, perceived self-efficacy holds potential to represent a good subjective indicator for objective human behavior in a web 2.0 e-learning environment.

Appendix

Description of regular and special cases

- *Regular cases: Login, row of actions, logout*
  In the regular cases, the algorithm iterated over the user log entries until a login action was found. The time of the *login* action was then saved, and a session created. Next, all following actions were included into the created session up to the time a *logout* action occurred. The time of the *logout* action was saved and marked as the end of the session, resulting in the calculation of the duration of the session. The algorithm ended the session and saved the session for the individual user including all actions performed, start time, end time, and duration.
- *Special case 1: Login, row of actions, no logout*
  In some cases, the user did not perform a logout action. If a user was performing a *login* action again, before he performed a *logout* action, the algorithm took the time stamp of the last performed action after the login and created an artificial logout action. The second *login* without a logout between them created a new session.
- *Special case 2: no login, row of actions, logout*
  If the algorithm found actions that were limited by a logout action, but had no login action, the time stamp of the first action in this row was used to create an artificial login action.
- *Special case 3: no login, row of actions, no logout*
  If the algorithm found a row of actions without a *login* action and *logout* action, the log entries were discarded. This procedure was necessary because no statement about the actual length of the session would be possible.

Notes

Authors

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Contributions

- Study design: MM, FM, CK, CI
- Development and methodology: MM, TH, CI, CK
- Collection of data: MM, TH
- Data analysis: MM, TH
- Writing sections of the manuscript: MM, TH, CK
- Manuscript revision: TH, DP, FM, CI, CK

Competing interests

The authors declare that they have no competing interests.

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