This literature review examines the published findings from research studies dealing with web-based learning (WBL) and measured gender effects. Particularly, the review presents a theoretical model of WBL which distinguishes between human, technology, and course characteristics as basis for instructional events. Instructional events (e.g., assessing performance) support learning and are related to motivational (e.g., goal setting), cognitive (e.g., monitoring), and emotional processes (e.g., positive feelings). These processes are postulated to influence learning outcomes (e.g., interest, knowledge, and satisfaction). Based on this model, a meta-analysis of 14 empirical studies dealing with WBL and gender effects was conducted. Results suggested that gender effects are insignificant at all levels of the postulated model. Discussions concerned theoretical as well as methodological aspects of gender-related research in the field of WBL. Finally, recommendations for improving future research and educational practice are given.
A significant increase in web-based learning (WBL) within schools and universities across many parts of the world gives rise to concern about gender-related differences. This concern refers to the fact that there are significant differences in abilities for learning in general of males and females (see, for example, the reviews from Halpern, 2000; Weiman, 2001; or Whitley, 1997). There are also various gender differences which were identified within learning from computer-based technologies (Lal, 2002). As WBL represents a new environment for learning, which differs from traditional non-computer-based and computer-based classroom settings in many ways, it is an open question, whether gender differences also exist within WBL. To answer this question, a theory- and research-based analysis of existing findings related to WBL and gender was undertaken.

Within a first step of this analysis, a theoretical model of WBL was developed to classify given results. Such a model should make it possible that (a) gender-effects can be identified at different stages of WBL, that (b) gender effects can be related to interaction or side effects, and that (c) gender effects and related shortcomings and inconclusive findings of given research in the field of WBL can be discovered (Lucas, 2002). The model would also help to anchor concepts from gender research in the field of WBL. For example, the concepts of gender inequity or of sex role stereotyping (Weiman, 2001) can be transformed into the field of WBL by asking which factors from the theoretical model contribute to the extent to which females and males are treated equally by the WBL environment.

In a second step, a meta-analysis considering empirical studies in the field of WBL and gender was conducted. This meta-analysis had an exploratory and a general character as it was assumed that the number, quality, and specificity of gender-related studies in the new field of research on WBL are not sufficient enough to achieve a comprehensive estimation of gender effects in different learning-related aspects (Cooper & Hedges, 1994). Results of the meta-analysis should help to identify not only statistically significant, but also practically relevant gender differences, because the question of practical significance was often overlooked in gender studies so far (Lee, 2000).

Within a third step, the results of the meta-analysis will be discussed considering the following assumptions: (a) Gender-related studies in WBL are not well founded in theoretical matters as many researchers see gender as a control variable without formulated model-related hypotheses concerning effects on learning processes or outcomes. Another reason for theoretical shortcomings can be found in the fact that WBL and related research is
more technologically than psychologically driven (Astleitner, 2001). Such an orientation focuses more on technical inventions than on the question which specific learning processes occur in WBL and how they are, in detail, influenced by gender. (b) As the field of gender-related research in WBL is relatively new, research findings will mostly be based on an univariate analysis of gender effects, lacking a multivariate orientation (Felix, 2001). Only such an orientation could help to identify gender effects that are based on the interaction with other factors, or that show unique amounts of variances in dependent variables which can be attributed to gender alone and not to confounding effects. (c) Studies related to traditional ways of computer-based learning and/or distance education identified considerable gender differences (Moore & Anderson, 2003). As females become more and more familiar with the Internet, gender differences should be small in WBL (Gunn, McSporran, Macleod, & French, 2003). As environments of WBL are adaptable and therefore allow many different ways of learning, gender differences can be assumed as insignificant, because learning can easily be regulated based on individual requirements (Astleitner, Brünken, & Leutner, 2003).

AN INTEGRATED MODEL OF WBL

The meta-analysis will be related to a theoretical model to get a comprehensive and a theory-based view of the current situation in gender-related research in the field of WBL. Figure 1 shows an integrated model of WBL. WBL represents learning within “a hypermedia-based instructional program which utilizes the attributes and resources of the WWW to create a meaningful learning environment where learning is fostered and supported” (Khan, 1997, p. 6). According to Astleitner (2003, p. 37), WBL can further be described as:

- interactive (i.e., students can interact with each other, with tutors, and with facilities on the Web);
- multimedia (i.e., text, graphic, audio, video, or animation);
- open (i.e., students have the possibility to visit other sites or the WWW);
- with synchronous and asynchronous computer-mediated communication (CMC) and other Internet applications (e.g., online group collaboration tools);
human- and computer-driven (i.e., learning is supported by human tutors or other students on- or offline, but also by software); and

- device, distance, and time independent (i.e., students can enroll in a WBL course from any place in the world, using any computer platform at any time of day).

The model represents an integration and expansion of the following models: a model of multimedia effects on learning from Hede (2002), a model to foster web-based collaborative learning from Ng and Ma (2002), and a model of the effective dimensions of interactive learning on the WWW from Reeves (2003).

Figure 1. An integrated model of web-based learning
Within this model, it is assumed that human characteristics, such as gender, together with technology and course attributes represent important conditions for WBL. Individual learners, groups of learners, instructors, instructional systems, and learning materials realize—based on human characteristics, technology, and course attributes—instructional events which support learning. Instructional events influence motivational, cognitive, and emotional processes of a learner. These processes lead to certain learning outcomes. Learning outcomes themselves influence student characteristics and learning processes in an iterative process.

Within the variables of human characteristics, gender, cultural habits, preknowledge, preskills, and attitudes are distinguished for individual learners, groups of learners, and instructors. Technological aspects concern visual/auditory input, access, usability, reliability, and using tools such as computer-mediated communication (CMC), or assessment and management capabilities. Course attributes refer to subject area, level (e.g., basic or advanced and theory-based or production-based), and organizational context (e.g., considering professional duties of learners). Instructional events (from motivating to enhancing retention and transfer) are based on group-, instructor-, system-, and material-related activities. Instructional events influence motivational processes (i.e., goal setting and action control), cognitive processes (i.e., attention, processing with searching, organizing, and integrating information, storage, or monitoring), and emotional processes (consisting of positive feelings like sympathy or pleasure and of negative feelings like fear, envy, or anger). These processes produce learning outcomes which are cognitive (knowledge and skills), motivational (interest and persistence), and/or emotional (satisfaction).

The Role of Gender Within the Integrated Model of WBL

From a theoretical point of view, gender effects in WBL are influenced by three different types of factors. Such factors can:

- accumulate; or
- compensate effects from gender; or
- have null effects in relation to gender.
An accumulation effect is given, when gender differences are increased by certain other learning conditions and processes. For example, gender differences in WBL might be especially high, when course content concerns spatial navigation (with advantages for males) or language education (with advantages for females). A compensation effect means that gender effects exist, but that they are decreased by certain learning conditions or processes. For example, special instructional events (like motivating, providing organization, or giving feedback) can reduce certain given gender differences in cognitive processing (like searching and finding new information). A null effect means that a factor does not have any effect on gender or on other factors in interaction with gender. For example, females tend to be more sensitive to touch, odours, or taste, but within WBL environments these kinds of experiences are not available and can therefore not influence learning (Weiman, 2001).

At the moment, it must be clear, that the accumulative, compensative, or zero power of a factor within the integrated model of WBL cannot be specified exactly. It can only be speculated about the type of power a factor shows, because testing the type of power needs sophisticated research designs (e.g., sequential testing methods) which cannot be found in existing studies on gender and WBL. However, based on this article, the different powers can be put into the focus of empirical research.

**EFFECTS OF GENDER RELATED TO THE INTEGRATED MODEL OF WBL**

The effects of gender can be anchored within the integrated model of WBL based on the results of the meta-analysis.

**Research Methods**

This review is based on studies which deal with measured effects of gender on WBL outcomes. That means that studies have to be empirical (based on data from the learners). Non-empirical studies dealing with WBL or empirical studies which did not report any statistical data were excluded. Furthermore, only research studies on WBL environments were analyzed in which all mentioned features of WBL were well-balanced, implemented, and
used for supporting learning processes and outcomes. Learning is defined, in relation to the environmental aspect of WBL, as changes in the learner’s behavior as a function of instructional interventions. As target group, adults (university/college students, lifelong learners in continuing education, etc.) and school-children were selected.

This review was based on 14 research studies which were published from the years 1997 until 2003 within online journals on educational technology or which were identified by Internet searches using Google (URL http://www.google.com). On a first round, the title in combination with the abstract or an abstract-like information was reviewed. Many documents were excluded on this general review, because (a) they were not gender-effect-testing studies, but exploratory case studies labeled as “tests”; (b) they were gender-effect-testing studies, but not located in the field of WBL; or (c) they were gender-effect-testing studies in the field of WBL, but they did not report any statistical data. After the second round of reviewing, in which all parts of a study were examined based on usual scientific criteria for empirical research (i.e., reliability and validity), 14 empirical studies remained to be considered and included for this review. They formed the basis for reporting on WBL and gender effects.

For computing the effect sizes (ES), the meta-analysis software META (Kenny, 2003) was used. ES were calculated only for those studies which reported sufficient statistical information (means, standard deviations, p-values, degrees of freedom, or test statistics). When there were no statistical significant differences found on a gender test, then ES were set to 0. Other studies which did not report sufficient statistical information were also included within this study, but no ES were computed. At least, within these studies, significant p-values had to be presented in order to be considered within this review.

**Results from the Meta-Analysis**

Tables 1 and 2 show the results of the meta-analysis concerning learning conditions, processes, and outcomes.
Table 1  
Significant and Nonsignificant Gender Differences in WBL (Learning Conditions and Processes)

<table>
<thead>
<tr>
<th>Dependent variables</th>
<th>Effects F(emale): M(ale)</th>
<th>Effect sizes</th>
<th>Studies</th>
<th>Study attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human characteristics</td>
<td></td>
<td></td>
<td>Study attributes</td>
<td></td>
</tr>
<tr>
<td>Pragmatic learning style</td>
<td>F&gt;M</td>
<td>NC</td>
<td>Logan &amp; Thomas (2002)</td>
<td>n=46 university students, computing</td>
</tr>
<tr>
<td></td>
<td>(p&lt;.01)</td>
<td>ES = .99</td>
<td>Hall &amp; Hickman (1999)</td>
<td>n=27 university students, psychology</td>
</tr>
<tr>
<td>Technology</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual input (preference)</td>
<td>F&lt;M</td>
<td>ES = .99</td>
<td>Ory, Bullock, &amp; Burnaska (1997)</td>
<td>n=174 university courses resp. faculty</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Felix (2001)</td>
<td>n=63 university students, language</td>
</tr>
<tr>
<td>Instructional events</td>
<td></td>
<td></td>
<td>Ory, Bullock, &amp; Burnaska (1997)</td>
<td>n=40 university courses, n=2151 students</td>
</tr>
<tr>
<td>Group/instructor</td>
<td>F=M</td>
<td>ES = 0</td>
<td>Lucas (2002)</td>
<td>n=174 university courses resp. faculty</td>
</tr>
<tr>
<td>discussion/conferencing</td>
<td>F=M</td>
<td>ES = 0</td>
<td>Felix (2001)</td>
<td>n=63 university students, language</td>
</tr>
<tr>
<td>Material (using content module)</td>
<td>F&gt;M</td>
<td>ES = .17</td>
<td>Lucas (2002)</td>
<td>n=348 university students, environmental science</td>
</tr>
<tr>
<td></td>
<td>F&lt;M</td>
<td>ES = 0</td>
<td>Felix (2001)</td>
<td>n=40 university courses, n=2151 students</td>
</tr>
<tr>
<td>Cognitive processes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attention (number of messages)</td>
<td>F&lt;M</td>
<td>ES = .22</td>
<td>Li (2002)</td>
<td>n=22 6-grade students,</td>
</tr>
<tr>
<td>(length of message)</td>
<td>F&lt;M</td>
<td>ES = .24</td>
<td>Li (2002)</td>
<td></td>
</tr>
<tr>
<td>Processing (asking)</td>
<td>F&gt;M</td>
<td>NC</td>
<td>Li (2002)</td>
<td></td>
</tr>
<tr>
<td>Processing (explaining, presenting, suggesting, expressing)</td>
<td>F=M</td>
<td>ES = 0</td>
<td>Li (2002)</td>
<td></td>
</tr>
<tr>
<td>Processing (submitting, scanning)</td>
<td>F&lt;M</td>
<td>ES = 2.70</td>
<td>Roy &amp; Chi (2003)</td>
<td>n=14 8-grade students, biology</td>
</tr>
<tr>
<td>Monitoring (using quiz)</td>
<td>F&gt;M</td>
<td>ES = 0.19</td>
<td>Lucas (2002)</td>
<td>n=174 university courses resp. faculty</td>
</tr>
<tr>
<td>Monitoring (calendar, syllabus)</td>
<td>F=M</td>
<td>ES = 0</td>
<td>Lucas (2002)</td>
<td></td>
</tr>
</tbody>
</table>

Note. NC = not calculable because of missing statistical information.
Table 2
Significant and Nonsignificant Gender Differences in WBL
(Learning Outcomes)

<table>
<thead>
<tr>
<th>Dependent variables</th>
<th>Effects F (e m a l e) : M(ale)</th>
<th>Effect sizes</th>
<th>Studies</th>
<th>Study attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning outcomes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interest/persistence (self-efficacy)</td>
<td>F&lt; M</td>
<td>ES=.83</td>
<td>Zhang, Li, Duan, &amp; Wu (2001)</td>
<td>n=112 university students with 1-2 years of experience</td>
</tr>
<tr>
<td>Knowledge/skills (assignments)</td>
<td>F= M</td>
<td>ES=0</td>
<td>Brown et al. (2002)</td>
<td>n=234 9-12-grade students, politics</td>
</tr>
<tr>
<td>Knowledge/skills (final exams)</td>
<td>F= M</td>
<td>ES=0</td>
<td>Shany &amp; Nachmias (2000)</td>
<td>n=110 8-9-grade students, computer education</td>
</tr>
<tr>
<td>Knowledge/skills (grades)</td>
<td>F&gt; M</td>
<td>ES=.17</td>
<td>Benbunan-Fich &amp; Hiltz (2002)</td>
<td>n=1244 university students</td>
</tr>
<tr>
<td>Satisfaction (perceived achievements)</td>
<td>F&lt; M</td>
<td>ES=.42</td>
<td>Zhang, Li, Duan, &amp; Wu (2001)</td>
<td>n=112 university students with 1-2 years of experience</td>
</tr>
<tr>
<td></td>
<td>F= M</td>
<td>ES=0</td>
<td>Koohang &amp; Durante (2003)</td>
<td>n=111 university students, management</td>
</tr>
</tbody>
</table>
When considering the given results within the included studies and when considering the integrated model of WBL, several significant and non-significant gender effects were identified. Females had a stronger pragmatic learning style than males. Males preferred, as visual input of a learning environment, a more complex background in comparison to females. Males and females did not differ in their quantity and quality of using different instructional events. In respect to using contents of WBL, one study suggested that females more often used the learning modules than males, and another study suggested that females spent less time with the learning modules in comparison to males (what can probably be attributed to the subject area of language learning in which females have, in general, advantages in comparison to males). Furthermore, females had lower attention (measured in number and length of messages) and less frequently submitting and scanning as searching behaviour in comparison to males. Females and males were equal in certain frequencies of processing (i.e., giving explanations, presenting opinions, making suggestions, or expressing disbelief) and of monitoring (i.e., using calendar and syllabus). Females also presented more frequently than males certain types of processing (asking information in a mathematics/science course) and of monitoring (using quiz). Concerning learning outcomes, results showed that females and males were equal in many measured variables (i.e., interest/persistence; [measured as self-efficacy], knowledge/skills [assignments, exams, or grades], and satisfaction [perceived achievements]). In one study, females had lower interest/persistence after WBL and lower satisfaction with the learning experience. In another study, females had higher grades in comparison to males.

Based on the single ES, the average size of the ES can be computed: the mean of all computed ES is 0.30 (with a standard deviation of 0.63). When not considering the results from Roy and Chi (2003)—because of small sample size and because of extreme deviation from the other results - the mean of all ES would be 0.17 (with a standard deviation of 0.30). An ES of 0.17 means that, at average, less than 1% of the variance of the dependent variables ($R^2$) can be traced back to gender (Lipsey, 1990, p. 58). In both cases, the average ES is small according to Cohen (1977), which means that gender only has a very small practically relevant effect on different variables which are important in WBL.
DISCUSSIONS

Within this article, first, a theoretical model of WBL was developed in order to classify gender effects. This model is—to some degree—eclectic as it combines concepts from different theoretical backgrounds without presenting an original innovative theoretical approach. However, this model was not developed to focus upon innovation, but to integrate different effects of gender within WBL. Such a model is a first step in the development of a theory on gender effects within WBL. The development of such a model is necessary, because many of the reported studies were not based on a known theory as assumed in the first general assumption of this article. Some studies did not relate to a theory at all (McSporran & Young, 2001). Some studies were not based on a theory, but on findings from other studies (Felix, 2001). A small percentage of the studies was based on traditional theories of learning, but without anchoring in detail gender effects or aspects of WBL (Zhang, Li, Duan, & Wu, 2001). Only one identified study was based on a theoretical model considering learning conditions of WBL and gender, whereas gender and related effects were not specified in detail (Benbunan-Fich & Hiltz, 2002). Overall, the theoretical situation in research on gender and WBL is not satisfactory.

This situation might also be the reason, why existing research is based, as assumed, more on an univariate in comparison to a multivariate orientation. Many studies tested the effects of gender without considering other variables which might also influence the dependent variable, especially in interaction with gender (Gunn, McSporran, Macleod, & French, 2003). Only within three studies, the combined effects from gender (together with the type of course) on WBL were tested with advanced statistical methods (Benbunan-Fich & Hiltz, 2002; Felix, 2001; Hall & Hickman, 1999).

Theoretical shortcomings and a lacking multivariate orientation represent some reasons why—within the presented meta-analysis and as assumed—only insignificant gender effects on WBL were identified. As there are many small or even null effects of gender on the variables of the integrated model, it remains an open question in which way gender influences WBL. Especially, the usage of instructional events did not differ between females and males, although there were small differences in cognitive processes (except in the case of searching behaviour) and on learning outcomes. These results are conclusive in some way. When there are no significant gender differences in the usage of instructional events, then there should be no differences in
cognitive processing and in learning outcomes. This argument corresponds with the given data of the meta-analysis. But, this interpretation does not mean, that there are only null effects from gender and no accumulation or compensation effects. It is well known from cognitive research that there are gender differences in certain areas of learning or knowledge acquisition (Halpern, 2000). Within the given studies, there are, for example, different subject areas to be taught which traditionally favour females (such as language education) and others which favour males (such as mathematics or computing). One could expect that even within WBL, these different gender-related advantages or disadvantages of learning result in different learning outcomes. But, this is not the case. Based on this circumstance, it can be concluded, that there is a compensatory mechanism in WBL: some features of WBL have a positive influence on learning, but similar results can also be achieved by other factors and their combinations. What seems to be important is an “open learning mix” in which different features of WBL are combined in a way that learning is supported individually. But, this explanation is also not supported by the data, because there are no remarkable gender differences within the usage of instructional events.

So, a first conclusive explanation for the given results might be: there are gender differences in cognitive processing of information, but these gender differences can be decreased by certain features of WBL and their different usage. Such usage patterns and related cognitive processes are not yet analyzed sufficiently to support this explanation. Future research has to focus, on the one hand, generally on processes of information use and learning, and, on the other hand, especially on motivational and emotional processes, which are overlooked in given research so far. A second explanation might be that practically relevant gender effects can only be observed when strong accumulating effects are given. For example, females may outperform males if the subject area is language education (with disadvantages for males); if at the same time males cannot compensate a lack of knowledge by increased learning time or by asking tutors; and if at the same time males do not have more motivation to learn than females. Future research in the field of WBL and gender differences should concentrate on such accumulating effects which produce gender inequity or sex-role stereotyping.

Significant gender differences in computer-based learning were reported for many years in the past (Ory, Bullock, & Burnaska, 1997). The given meta-analysis does not support these results. Many studies in the past identified differences in attitudes about computers and computer-based learning...
(Kadijevich, 2000). However, in this study, attitudes did not play a significant role, which can explain the difference to other findings. As a general reason for this difference, it can be stated that computer systems are easier to handle and support learning more successfully in comparison to systems designed several years ago (Felix, 2001). Another reason might be that females and males reached a point of agreement about the salience of information technology in their work and study (Gunn, McSporran, Macleod, & French, 2003). Another reason might be that females are more interested in using computers than in earlier times, because the Internet offers experiences, which are not male-dominated (discussion groups for females). Finally, females are more skilled in using computers, because computers are available in schools and at home, together with institutionalized and non-institutionalized forms of computer education (Lucas, 2003).

It must also be mentioned that there are some methodological problems within this study. The meta-analysis is based on studies with learners from different ages or backgrounds. Therefore, the problem of comparing “apples with pears” arises: gender differences of high-school students might be different from gender differences of adults. However, within this meta-analysis not only an overall effect size was computed, but also single effect sizes which make it possible to focus on different groups of learners. It must also be criticized that the studies, which were included in the meta-analysis, often did not use standardized measures for gender effects or related learning conditions (e.g., the measurement of gender inequity). Therefore, overall, the validity of the studies must be questioned. Another problem concerning the validity comes from the fact that, when gender differences were discovered, no theoretically and/or empirically founded reasons were given, which could explain the findings. Especially, only within a few studies, it was reported, which gender-related variables were responsible for the different performance outcomes (Roy & Chi, 2003).

Also, the meta-analysis cannot be considered as a proof of the integrated model, because some of the research variables (self-efficacy from Zhang, Li, Duan, & Wu, 2001) did not match exactly with the variables of the integrated model (e.g., the learning outcome of interest or persistency). The integrated model had more of the function to categorize effective factors within a theoretical framework of variables. It can also not be expected that other researchers will design their research based on the presented integrated model in the future, because research in WBL lies within many different areas of research. However, such a model should stimulate the building of
theories in the field of gender and WBL.

Based on the results of this study, it cannot be recommended for instructional designers that females should be treated differently in WBL in comparison to males. However, females and males have distinct needs and the flexibility of the learning environment, so as to offer a supportive, adaptive, and effective learning context, is appropriate towards the realization of the learner’s success. It can also be recommended that within learning environments, (theory-based) data about multi-dimensional aspects of learning (i.e., cognitive, motivational, and emotional processes) should be gathered as often as possible in the long run. Such data can help to explore gender effects on WBL on a more comprehensive basis in comparison with the studies which were included in this meta-analysis. In that way, the findings of this study should not decrease activities in research on WBL and gender. Probably the gender gap in technology-related education like WBL begins to close, but there is still a considerable way to go. The analysed evidence suggests that a well-designed environment for WBL can significantly assist in overcoming gender-related differences, but it does not suggest that there are no such differences. The evidence also does not contradict other gender-related WBL studies which identified numerous gender differences in learning styles, participation barriers, or communication patterns (Blum, 1999), because this study was focused on learning and on variables closely related to learning. The evidence also does not open the “black box” to inform, which specific characteristics of WBL environments help female and male students earn higher achievements and enhance levels of satisfaction. More longitudinal quasi-experimental field studies that look at the process as well as on the outcome of specific and multiple types of learning would help to get a more focused view of gender effects on WBL.

References


Author Note

Correspondence concerning this article should be addressed to: Hermann Astleitner, University of Salzburg, Akademiestrasse 26, A-5020 Salzburg, Austria; E-mail: Hermann.Astileitner@Sbg.Ac.At. This study is related to the Virtual Thinking School-Project from the Cornelsen-Foundation (Germany) (T066/11261/2001).