Examining Gender Differences in Self-Regulated Learning with MetaTutor

David A. Organista, Daryn A. Dever, and Roger Azevedo

[Dorganista@knights.ucf.edu,](mailto:Dorganista@knights.ucf.edu) [ddever@knights.ucf.edu,](mailto:ddever@knights.ucf.edu) Roger.Azevedo@ucf.edu

**Abstract.**

Intelligent tutoring systems (ITSs)have been used to scaffold students’ self-regulated learning (SRL), or one’s monitoring and regulating cognitive, affective, metacognitive, and motivational processes, across various STEM topics. In this study, MetaTutor, an ITS, implements pedagogical agents (PAs) to guide college students’ SRL while learning about the human circulatory system. 120 college students were randomly assigned to one of two conditions: (1) the *Control* condition where participants did not receive support from pedagogical agents and could only self-initiate SRL strategies; and (2) the *Prompt and Feedback* condition where participants were able to self-initiate SRL strategies but were also prompted by the PA to engage in strategies and provided feedback on their use of the strategy. A 2 x 2 factorial design (Gender: males vs females, and Scaffolding: no scaffolding vs adaptive scaffolding) was used to compare male and female students across the two conditions on learning outcomes and SRL strategy use. While analyses did not find significant differences in learning outcomes between genders, results showed that females had greater frequency of note-taking, spend more time taking notes, and self-initiated more note-taking behaviors compared to males. Differences in strategy use like note-taking may reflect gender-specific differences not affecting learning outcomes when compared between genders. Results support further examination of how SRL scaffolding should adapt to gender for possible improvements in learning outcomes.

**Introduction.**

Self-regulated learning (SRL) is the process by which learners monitor and regulate their own cognition, affect, metacognition, and motivation (Winne, 2018). SRL strategies can be conceptualized within a hierarchy, organized into 35 micro-level processes grouped under 5 macro-levels (Greene & Azevedo, 2009). Strategy use, a macro-level process, includes micro-level processes of summarization and note-taking where the quality of learners’ strategy deployment provides insight into successful learning. For example, greater quality of note taking reflects greater learners’ cognitive success where the process itself may be beneficial for learning (Azevedo et al. 2022; Trevors et al., 2014).

The overall learning goal for all learners in this study was to learn about the human circulatory system using an intelligent tutoring system (ITS), MetaTutor (Azevedo et al. 2022) which integrates pedagogical agents (PAs) to scaffold and foster learners’ SRL strategy use. Studies have shown learners with PA adaptive scaffolding had higher learning outcomes and used a wider range of SRL strategies (Azevedo et al. 2022; Dever et al., 2022; Trevors et al., 2014) suggesting that adaptive scaffolding is crucial for learners’ SRL, especially when considering the individual differences across learners.

Males and females have been shown to use SRL strategies differently, which is consistent with prior research showing gender differences in problem-solving techniques across age groups (Arroyo, 2003; Wei et al., 2012). For example, studies on gender differences have shown that females have been more receptive to seeking and accepting help from PAseven when having mastered similar number of topics where females have benefited more both affectively and cognitively from affective PA scaffolding (Arroyo, 2003; Arroyo et al., 2013). These different approaches may reflect the kinds of help the genders (male/female) need from ITSs. Other studies have reported females to have better general attitudes while learning with ITSs even without PAs despite female learners having higher affective needs in STEM subjects (Arroyo et al., 2011). It is important to note that apparent differences in strategy use and performance may not reflect a common advantage between the genders. For example, in Wei et al.’s study (2012), math performance favored females although results suggested the advantage was due to their language processing advantage and not their basic numerical processing or similar cognitive abilities.

Despite these studies, there is a gap in the literature examining differences in learning outcomes and SRL strategy use while learning with (non-affective) PAs. This roundtable submission attempts to expand current literature by examining how learners’ use of PA scaffolding and SRL strategies while learning with an ITS is attributed to gender differences. Overall, we ask: Should SRL scaffolding be gender dependent? To answer this question, three research questions are answered: (1) Are there differences between males’ and females’ learning gains, accounting for PA support? (2) Are there differences between males’ and females’ SRL strategy use, accounting for PA support? (3) To what extent do males and females rely on PAs to prompt their SRL strategy usage?

**Method, Materials, and Coding and Scoring.**

120 undergraduate students ( *M*\_age = 20.4; *SD*\_age = 3.17; 56% female) were randomly assigned to one of two conditions, the *Control* (N = 60) and the PA *Prompt and Feedback* (PF; N = 60). Within the *Control* condition, participants did not receive PA support and could only self-initiate SRL strategies. Within the PF condition, participants were able to self-initiate SRL strategies, but were also prompted by the PA to engage in strategies based on an extensive set of production rules and were provided feedback (Azevedo et al. 2022).

Log-file data captured when learners engaged in different types of SRL strategies using an SRL palette embedded in the system’s interface. Within this roundtable, we focus on micro-level processes nested within macro-process including note-taking, summarizing, re-reading, and coordinating informational sources. Gender was determined using a self-report demographics questionnaire. Learning gains were calculated using normalized learning gain scores based on each student’s pre- and post-test scores about the human circulatory system (see Marx & Cummings, 2007).

**Results.**

*Are there differences between males’ and females’ learning gains, accounting for PA support?* A two-way ANOVA was run using both gender and condition as between-subjects variables and learning gain as the dependent variable. Results showed an overall significant effect (*F*(3,116) =

33.9, *p* < .01). While a significant difference exists between conditions (*t*(111.52) = 9.94, *p* < .01) where those in the PF condition (*M* = 0.06, *SD* = 0.02) had greater learning gains than those in the *Control* condition (*M* = 0.01, *SD* = 0.03), learning gains are not significantly different between genders or with the interaction between condition and genders (*p* > .05).

*Are there differences between males’ and females’ SRL strategy use, accounting for PA support?* A mixed ANOVA did not reveal differences between genders in their overall strategy use frequency across note-taking, summarization, re-reading, and coordinating informational sources. However, A two-way ANOVA revealed a significant difference in the frequency of note-taking (*F*(3,116) = 5.25, *p* < .01; *t* = -2.16, *p* < .05) between genders where females had significantly greater note-taking frequencies (*M* = 14.7, *SD* = 16.0) than males (*M* = 6.19, *SD* = 0 8.74; *t* = -2.16, *p* < .05). Another two-way ANOVA revealed a significant main effect on the total time spent taking notes where females (*M* = 804.79s, *SD* = 1077.8s) had a greater note-taking duration than males (*M* = 256.4s, *SD* = 488.8s; *t* = -2.88, *p* < .01).

*To what extent do males and females rely on PAs to prompt their SRL strategy usage?* For this question, we divided participants from the full dataset if they were assigned to the PF condition to find possible gender differences in the number of times they were prompted by a PA to engage in note-taking versus when the SRL strategy was self-initiated. Two t-tests found that while males’ (*M* = 5.77, *SD* = 8.73) and females’ (*M* = 14.4, *SD* = 16.1) self-initiated SRL note-taking strategy frequencies differed, where females self-initiated more often (*t* (97.6) = 3.70, *p* < .01), the PA did not adapt to prompt a different number of times between the genders (*p* > .05).

**Discussion**

Are there gender differences in self-regulated learning? Our study showed that while there are no significant differences in learning outcomes between genders, there are differences in strategy use. Results found that females had greater frequency, spend more time, and self-initiated more on note-taking behaviors compared to males. Differences in strategy use like note-taking within females may reflect a behavioral gender-specific difference not leading to improved learning outcomes when compared with males. However, because males are relying significantly more on PAs from SRL strategy use, we suggest PAs adapt by prompting males more frequently to use strategies like note-taking as learners with PA scaffolding have shown higher learning outcomes.

Considering the cognitive/affective predispositions of each gender, SRL scaffolding based on gender may help learners promote a positive relationship with advance STEM topics for the goal of gender equity in this field. According to Azevedo et al. (2022), the methods used to capture and measure learning should reflect the dynamic, cyclical, and non-linear learning model for system features to adapt to the individual student. To justify gender-dependent SRL support, more research needs to focus on the implications of differences in SRL process use between genders and how PAs in ITSs can leverage these differences to provide more individualized scaffolding. Future research should address the following: (1) If not cognitively, then how is the difference in note-taking benefiting female learners? (2) Is current PA scaffolding benefiting genders’ affect differently?

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