

Introduction

The ability to correctly identify species is a crucial and important skill to master for biologists. These skills are not only important core biology competencies, but important skills in a world with increasing environmental pressure, climate changes, and habitat loss. Providing the future workforce with the skills and competencies necessary to meet society's needs is a key deliverable of the educational system, and it is therefore a paradox that there is now a decreasing focus on learning plant and animal species, and the skills necessary to identify them (Lawler, 2016; Parkin, 2016). An especially difficult species group to identify, and that students find uninteresting is sedges (Latin: *Carex*).

- Identification tools

Traditionally, teaching and identification of sedges has been done with a textbook with dichotomous "keys". Based on characteristics of the sedge, students have to choose between two possibilities before moving to the next identification question. These keys (8-10 questions) are often comprehensive and require solid knowledge in technical term and morphology to master properly. In addition to be comprehensive and complex, the textbook is not well suited to bring along to fieldwork and other practical work.

An alternative to this traditional textbook method is "ArtsApp". ArtsApp is a mobile-application that allows students to identify the species more dynamically with the ability to choose amongst all the characteristics of the species, and thus starting with the easier ones instead of having to move down a dichotomous key. It contains pictures of the characters in questions, in addition to the textual descriptions. ArtsApp will also keep track of your progress in terms of how many species you have excluded and how many you have left before ending up with the correct species.

Based on the assumptions of Self-Determination Theory (Deci & Ryan, 1985) and previous work on e-learning, motivation and learning (Martens, Gulikers & Bastiaens; Jenö & Diseth, 2014), we proposed the following hypotheses:

- 1) The app contributes to higher achievement scores, perceived competence and intrinsic motivation compared to the book
- 2) Intrinsic motivation and perceived competence has an indirect effect between identification tool and achievement.
- 3) Intrinsic motivation, autonomous motivation, and autonomy support uniquely accounts for interest in identification and importance of knowing species

Methods

71 biology students were recruited for the experiment during a one-week field course in biology. A trained research assistant unaware of the research hypotheses assigned the students to a mobile-application condition (experimental-condition) and to a book-condition (control-condition).

The students were given two different envelopes containing different questionnaires. Students in the experimental-condition were then asked to answer some identification question using the mobile-application ArtsApp. The students in the control-condition were asked to use the traditional book Lids Flora. The students were then asked to conduct a post-experimental questionnaire assessing intrinsic motivation, perceived competence, autonomy support, autonomous and controlled motivation and interest/importance of identifying species.

Results

All study variables approximated a normal distribution (Table 1). The majority of the participants had no experience with species identification (71.8 %), while only a few had experience with this particular sedge (4.2 %). Almost two-fifth of the participants preferred the mobile-app over the book. There were no statistical significant results between gender, students who preferred the app, or students with previous experience with identification (p 's > .05) on achievement. Thus, gender was collapsed throughout the analyses.

Table 1

- Descriptive statistics

Measures	N	M	SD	Skewness	Kurtosis
Achievement	71	6.88	3.44	.72	.19
Intrinsic motivation	71	4.36	1.69	-.23	-.97
Perceived competence	71	2.98	1.13	.29	-.42
Autonomy support	71	4.85	.99	.03	-.58
Autonomous motivation	71	6.30	.74	-.92	.14
Controlled motivation	71	2.69	1.06	.37	-.52
Importance of knowing species	71	5.64	1.20	-.88	.40
Interest in identification of species	71	4.38	1.47	-.42	-.56

The results from t-tests (fig.1) show significant and medium effect sizes on all three variables as expected. Indirect SEM (fig.2) with 5000 bootstraps show significant relation and indirect effect of ArtsApp on achievement, mediated by intrinsic motivation. Lastly, hierarchical regression model (fig.3) show that intrinsic motivation and autonomous motivation uniquely predicts interest and importance in identification.

Figure 1

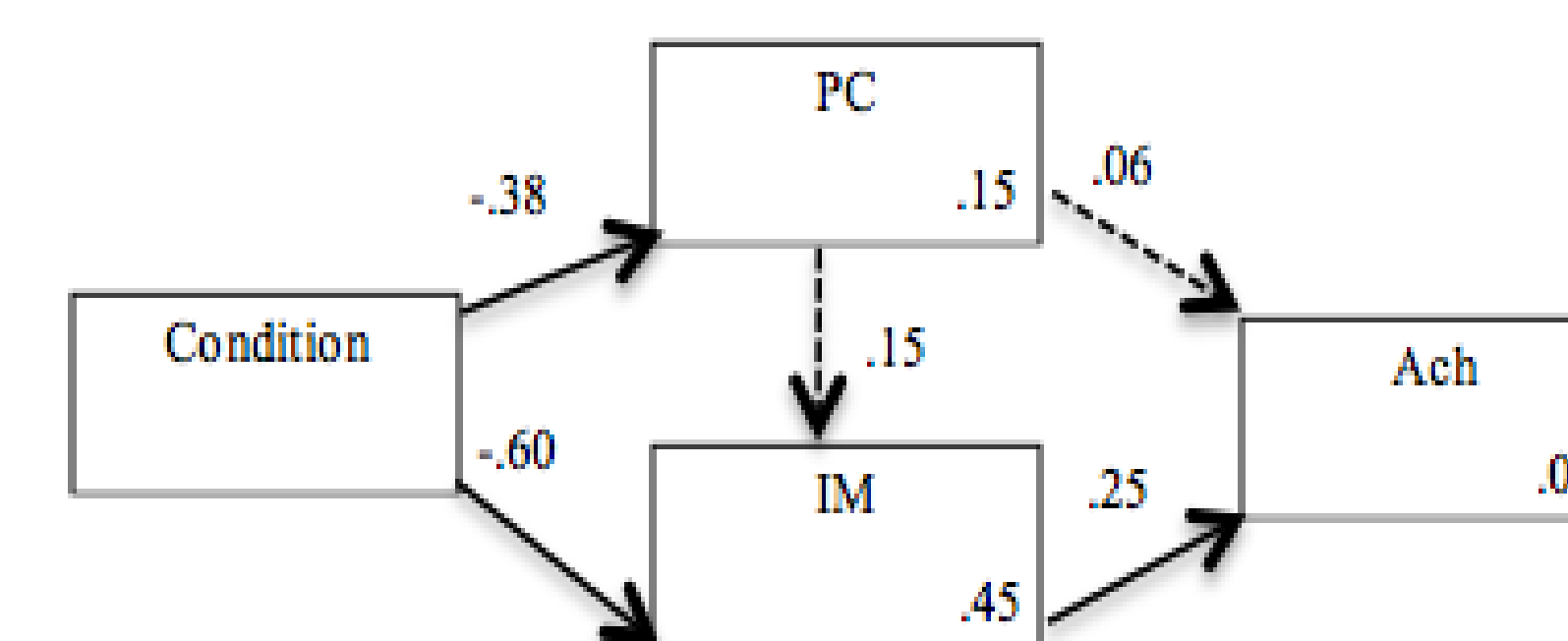
- Independent t-tests

	Experimental-condition		Control-condition		95% Confidence interval		t-test	d
	M	SD	M	SD	LL	UL		
Intrinsic motivation	5.44	1.23	3.24	1.31	1.59	2.80	7.24***	1.73
Perceived competence	3.41	1.19	2.54	.89	.37	1.36	3.44***	.82
Achievement	7.78	3.21	5.95	3.46	.21	.25	3.41*	.54

Note: Experimental-condition= Mobile-application
 Control-condition= Book

Figure 2

- Structural Equation Modeling



Note: Experimental-condition= Mobile-application. Control-condition= Book.
 $\chi^2/df=1.0226$, $p>.05$, CFI=1.00, NFI=.98, TLI=.99, RMSEA=.019 (.000-.318)

Figure 3

- Hierarchical regression model

Dependent variables	Interest in identification of species		Importance of knowing species			
	Predictor variables	β	R^2	Predictor variables	β	R^2
Step 1	Condition	-.010	.000	Condition	.055	.003
Step 2	Condition	.319*	.142**	Condition	.278	.069
	IM	.501***		IM	.340*	
Step 3	Condition	.254	.163**	Condition	.231	.079
	IM	.437**		IM	.294	
	Aut. Sup	.153		Aut. Sup	.109	
Step 4	Condition	.249	.216**	Condition	.227	.110
	IM	.429**		IM	.288	
	Aut. Sup	.057		Aut. Sup	.036	
	Con. Mot	.251*		Con. Mot	.191	
Step 5	Condition	.307*	.274***	Condition	.312*	.233**
	IM	.457**		IM	.330*	
	Aut. Sup	-.058		Aut. Sup	-.133	
	Con. Mot	.236*		Con. Mot	.170	
	Aut. Mot	.266*		Aut. Mot	.391**	

Conclusions

The overall aim of the study was to investigate how a mobile-application affected students' achievement compared to the traditional book employing a Self-Determination Theory perspective.

The present study adds to the mobile learning literature in several important ways. Firstly, we test, experimentally, the relation of mobile apps on well-established textbooks traditionally used by biologists in higher education. Secondly, by using a theoretical framework, we assess how the mobile app vs. textbook relates to several important indicators. Lastly, few studies have investigated the effect of e-learning in a SDT-approach, this study narrows this gap. However, more studies are needed to further understand how SDT-concepts relate to e-learning in higher education.

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