Mobile Learning and biodiversity – bridging the gap between outdoor and inquiry learning in pre-service science teacher education

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Abstract

This study presents first findings about the development of an inquiry-based approach in pre-service teacher training. After reports of students who felt ill equipped to teach adequately about biodiversity, an inquiry-based learning course about biodiversity was created, using new technologies and an autonomous and collaborative learning environment. Compared to the traditional university course, research showed advantages in motivational and cognitive areas within the students tested.

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1. Introduction

Biodiversity is considered an integral part of the biology curriculum in schools. Teaching about biodiversity in a holistic manner also includes aspects of socio-economic and ecological problems. This importance as a topic calls for a balanced and varied approach to teaching using methods that inspire the students. Menzel and Bögeholz (2009) highlight the need to “enhance sensitivity towards the […] species […] on a local scale” (p. 444). Especially the combination of active, participatory, collaborative learning methods and experiences within outdoor field activities showed evidence to improve biodiversity knowledge and attitudes (Ramadoss, 2011, Orion, 2003). In order to teach about these aspects of biodiversity in successful manner teachers need to draw connections to their students’ life and interests using multiple methods to create a meaningful learning environment. Acquiring these skills in teaching seems to be difficult for pre-service science teachers (Lindemann-M. Et al., 2009, Dikmenli, 2010). Mobile and location-based learning could be helpful to combine the contextual learning about local biodiversity, the personal engagement during self-directed learning activities and the young people’s every-day experiences with mobile technologies (cf. Kulska-Hulme & Traxler, 2007).

Science educators have suggested to use a twofold approach to teaching, the so called “pedagogical double-decker” (Wahl, 2001): In order to confidently use inquiry-based approaches, pre-service teachers are taught about...
biodiversity with the same methods they later need. Additionally, new technologies can be used to support self-determined learning (Ulbrich et al., 2010) which has been deemed a promising addition (Specht & Ebner, 2011).

2. Teaching Biodiversity through Inquiry

2.1. Inquiry-Based Science Education

The complex nature of natural sciences has been a challenge to teachers across schools and university. Simple teaching of known facts did not yield the expected outcome of confident students that know about, and know how to do science. The inquiry-based approach to Science Education (IBSE) is based on a moderate constructivist's view that active engagement with scientific topics in a supportive learning environment helps students to develop a sound base of subject and process knowledge. This happens through creating problems, case or research scenarios, experiential or laboratory settings that are presented to the students to work on either in groups or autonomously. The structure of these settings, as well as the level of guidance can vary according to the capability of the participants (cf. Asaya & Orgill, 2010, Minner et al., 2010). Mui and colleagues (2011) especially highlight the importance of collaboration during inquiry-based science education. All IBSE approaches share the aspect of inquiry as the main theme that allows the students to become researchers rather than recipients of a scientific topic, thus creating increased interest and motivation in the students.

2.2. The Inquiry-Based Biodiversity Teaching (InquiBiDT) Approach

Since several years, alternative approaches to biodiversity teaching have been developed and evaluated at the Ludwigsburg University of Education, combining collaborative, computer-supported learning environments with self-determined outdoor learning (Schaal & Randler, 2004; Schaal, 2009). The InquiBiDT approach is based on this former research and it uses an alternative form of university course about plant biodiversity based on IBSE. Subject matter and process knowledge can be acquired using inquiry-based learning strategies, supported by recent technology such as smartphones, wiki-platforms and other ICT tools. The course is divided three parts that use a common inquiry structure like gathering information, developing process knowledge and presenting results:

- Introductory Stage: The students receive a classic introduction to the kingdom of plants and relevant plant families, before they consolidate this knowledge in computer-supported collaborative learning and in a visit at a botanical garden. The students’ self-generated information base is used to collaboratively find suitable habitats for selected species. They map these habitats using Google Maps and geocaches. Additionally, the students create a wiki about the species in the specific habitat that is subsequently linked to a geocache that is positioned close to the site. At this stage, students carry out serious inquiry activities and they communicate their results adequately.
- Exploratory Stage: The student groups use their knowledge about habitats and plant morphology to compare their results with others on location using the geocaches and smartphones. During this stage, the students also identify further species of plants that occur at the site, completing the survey of plant biodiversity at selected sites.
- Results of the IBSE process: Stages 1 and 2 produce a collection of open access and location-based information about local plant species. Additionally, students summarize all information (photo, location) specific in a digital herbarium.

3. Methodology

3.1. Purpose of the study

The main goal of the study is to investigate the cognitive, motivational and attitudinal effects of the InquiBiDT approach in pre-service teacher training. In detail the following hypotheses should be verified:

1. The InquiBiDT learning environment is equal to other well-proven approaches in regard to cognitive and motivational outcome.
2. The InquiBiDT approach increases the teaching attitudes of pre-service teachers to use inquiry-based and outdoor approaches later on in their biology classes?

3.2. Procedure

The study was realized as quasi-experimental field research in pre-post-test design (see table 1) in regular lectures at the Ludwigsburg University of Education (southwestern Germany) during the spring/summer 2011. The lectures in biodiversity are mandatory for every teacher student, participants were randomly assigned to the three different courses.

For academic achievement within the field of plant biodiversity and taxonomy, a 30-minute concept mapping assessment was used (cf. Schaal et al, 2010). Within the concept mapping session, the students had to use 30 concepts (eg. Monocotyledonae, Rosaceae, single florescence) and 15 different relations (eg. has net leaf venation, has tetragonal stipe) for concept map construction. The students’ concept maps were compared to an expert concept map which was developed as an objective learning target by the authors. Furthermore, this expert map was validated by two other independent experts. The comparison to the expert map leads to a coefficient of correspondence, which spreads from -1 (completely negative of the student’s map) to +1 (identical to student’s map).

Students perceived motivational aspects were assessed using the German translation of the Intrinsic Motivation Inventory (IMI) developed by Deci and Ryan (2011). As sub-scales (i) interest/ enjoyment, (ii) perceived competence, (iii) value/ usefulness, (iv) perceived autonomy, (v) effort and (vi) felt pressure and tension were used. The IMI scale was adapted according to the perception of IBSE in biodiversity teaching. Computer-user self-efficacy was controlled using the CUSE-scale, CUSE and IMI were applied in former research (Schaal, 2010).

For the analysis of the attitudes towards using IBSE for teaching biodiversity (TA) a questionnaire was developed, asking about teaching biodiversity (I) as lecture (eg. "Learning biodiversity should be taught in a well-structured, teacher-centred environment"), (II) as self-determined and constructivist approach (eg. "Knowledge about biodiversity should be acquired as active inquiry") and (III) by using outdoor field-work (eg. "Knowledge about biodiversity can be efficiently achieved during active fieldwork"). Pilot testing of the scales revealed adequate reliability (Cronbach’s α > .60 for any sub-scale).

Semi-structured interviews were used for triangulation of the quantitative results and for formative evaluation. Out of three groups with low, medium and high level of technological expertise, nine students per course were randomly selected. The questions covered the student's experiences with the learning environment, the technology, the peer-collaboration and the factor of time.

Table 1. Overview of the study

<table>
<thead>
<tr>
<th>Pre-test</th>
<th>Concept Mapping of previous knowledge, teaching attitudes (TA), Intrinsic Motivation Inventory (IMI) towards IBSE in biodiversity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment (workload 3 ECTS)</td>
<td>INQUIBIDT Course autonomous-structured, co-operative, mobile technologies (N=25)</td>
</tr>
<tr>
<td>Post-test</td>
<td>Concept mapping of cognitive achievement, IMI, TA, Computer-user self-efficacy (CUSE), computer experience (CE), structured interviews (9 per course → N = 27)</td>
</tr>
</tbody>
</table>

4. Findings

4.1. Quantitative analyses of the questionnaires

The data was analysed using IBM SPSS 19 for MAC. All data was either normally distributed or it was adequately transformed. Data analysis was carried out using t-test, ANOVA and analysis of covariance (ANCOVA).

Students of all courses achieved higher scores from pre- to post-test throughout the treatment (t-test: T_{99} > 15.4, p < .001), pre- and post-test concept map correspondence were not correlated (Pearson R = -.10, p > .9). An ANOVA
analysis revealed significant group differences in students’ concept map correspondence after the treatment, while it did not differ before the intervention (see table 2).

Table 2. Means of concept map correspondence to an expert map

<table>
<thead>
<tr>
<th>Treatment</th>
<th>N</th>
<th>Concept map correspondence</th>
<th>Pre-Test Mean ± SD</th>
<th>Post-Test Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>InquiBiDT</td>
<td>25</td>
<td>-0.82 ± 0.04</td>
<td>-0.29 ± 0.20</td>
<td></td>
</tr>
<tr>
<td>Course 2</td>
<td>36</td>
<td>-0.81 ± 0.07</td>
<td>-0.34 ± 0.21</td>
<td></td>
</tr>
<tr>
<td>Course 3</td>
<td>28</td>
<td>-0.82 ± 0.08</td>
<td>-0.36 ± 0.23</td>
<td></td>
</tr>
</tbody>
</table>

Students within the InquiBiDT course reached the highest concept map correspondence compared to the learning target, followed by the students of course 2 and the lowest achievement was documented for the traditional lecture (ANOVA pre-test: \(F_{67} = 0.1, p > .89\); post-test: \(F_{74} = 3.9, p < .05, \eta^2 = .09\)).

Neither the CUSE nor the computer experience and the teaching attitudes differed in the three courses and therefore these scales were not respected for the further analysis.

The ANOVA analysis for the motivational variables revealed differences between the three courses just for the scales of perceived competence and value/ usefulness (ANOVA perceived competence pre-test: \(F_{74} = 0.34, p > .91\); post-test: \(F_{74} = 4.4, p < .05, \eta^2 = .1\). Value/ usefulness pre-test: \(F_{74} = 2.1, p > .13\); post-test: \(F_{74} = 3.4, p < .05, \eta^2 = .09\)). In both categories, the InquiBiDt course students reported the highest values.

Table 3. Means of perceived competence and value/ usefulness of the IMI scale (5-scale Lickert, 1 = low value 5 = high value)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>N</th>
<th>Perceived competence</th>
<th>Pre-Test Mean ± SD</th>
<th>Post-Test Mean ± SD</th>
<th>Value/ usefulness</th>
<th>Pre-Test Mean ± SD</th>
<th>Post-Test Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>InquiBiDT</td>
<td>25</td>
<td>2.3 ± .5</td>
<td>3.5 ± .7</td>
<td>4.1 ± .3</td>
<td>4.4 ± .4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Course 2</td>
<td>36</td>
<td>2.4 ± .6</td>
<td>3.1 ± .7</td>
<td>4.3 ± .4</td>
<td>4.2 ± .9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Course 3</td>
<td>28</td>
<td>2.3 ± .6</td>
<td>2.9 ± .6</td>
<td>4.1 ± .5</td>
<td>3.9 ± .5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The final model for the analysis of covariance (ANCOVA) consisted of the post-test concept map correspondence as dependent variable, the treatment was used as fixed factor and the perceived competence as well as the value/ usefulness were used as covariates. The results of the ANCOVA are presented in table 4:

Table 4. ANCOVA with the post-test concept map correspondence, explained variance of the model \(R^2 = .216\) (**p < .01, ***p < .001)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Significance</th>
<th>Partial (\eta^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected model</td>
<td>4</td>
<td>.223</td>
<td>4.963</td>
<td>.001***</td>
<td>.216</td>
</tr>
<tr>
<td>Treatment</td>
<td>2</td>
<td>.173</td>
<td>3.850</td>
<td>.026*</td>
<td>.097</td>
</tr>
<tr>
<td>Perceived competence</td>
<td>1</td>
<td>38.15</td>
<td>9.000</td>
<td>.004**</td>
<td>.111</td>
</tr>
<tr>
<td>Usefulness/ value</td>
<td>1</td>
<td>9.98</td>
<td>5.693</td>
<td>.020*</td>
<td>.073</td>
</tr>
</tbody>
</table>
4.2. Qualitative analyses of the interviews

The semi-structured interviews were conducted by an interviewer, who was trained for the study and provided assistance to the respondents if necessary. The interviews dealt with questions about the physical learning environment (e.g., "At which site do you think your learning process was the most effective?") about the use of technology (e.g., "To what extend the technology like GPS or mobile devices supported your personal learning process?"), about the factor of time (e.g., "Which task during the course was most time consuming?" or "Estimate the time you spent for the whole learning process in the course") and about the peer-collaboration (e.g., "Which aspects of the collaboration within your working group were advantageous or obstructive?").

The interviews were transcribed and then categorized by one person using the software MaxQDA. The categorization was randomly tested by another person and the inter-rater agreement was Cohen’s κ = 0.7. The qualitative results are presented in brief in the following list:

- **Physical learning environment:** The all respondents highlighted the importance of fieldwork. Students of the courses 2 and 3 wanted to have more outdoor experiences while the InquiBiDT students did not mention. But the latter complained about the studies in the botanical garden, which they considered not to be effective. Students of the InquiBiDT course and the course 2 highlighted the self-determined fieldwork, which they perceived as very valuable. Furthermore, the students of the InquiBiDT course stated that the fieldwork and the structuring of the information by mind maps would help them to memorize the plants and their taxonomy.

- **Use of technology:** Students of all courses reported about contradictory experiences depending on their personal technological skills. The experienced technology users easily applied the tools (Google Maps, Xmind for mind mapping, wiki) and devices (GPS receiver, digital camera), while the inexperienced students had to overcome some technical hints and thus they spent less time for “real learning” (INQ_3). The InquiBiDt course students highlighted the potential of mobile technologies to get students to learn directly in the field.

- **Peer collaboration:** Students of all courses highlighted the strength of cooperative and goal-oriented learning. Especially the InquiBiDT course students reported about some hints concerning the organization of collaboration, but they perceived positively the collaborative and self-determined learning.

- **Time as factor:** The students mainly spent between 40 and 60 hours of active learning time in total without any inter-course differences.

5. Conclusion

The results of this study are mainly in line with prior findings and theoretical assumptions. The pre-service teacher students were able to cope with the demanding challenge to organize their individual learning collaboratively. They were able to use the mobile technology for outdoor learning and they achieved similar or better results as the other students within traditional university lectures about biodiversity. These findings are similar to the results of Ruchter and colleagues (2010), who used mobile devices for environmental education at a flood plain site and compared it to traditional instruments (brochures, personal guides). They also reported about positive effects of mobile learning on environmental knowledge and motivation, especially for adult users. Payne (2009) reported about the use of wikis to support sustainability literacy successfully. She highlights the potential to engage learners in active knowledge construction. This might also be one reason for the advantages of the InquiBiDT course, where learners were strongly engaged in processing and creating knowledge as a part of IBSE, more than within the other courses. Structuring and constructing information about local biodiversity seems to be an effective way to learn about it (cf. Makaris, 2010).

The InquiBiDT course results show evidence for successful learning about biodiversity in the field and thus, it could be a way to give prospective teachers the experience of fruitful fieldwork. In this context Barrett (2007) described the importance of teachers’ subjectivities concerning fieldwork to implement it in their courses. The pre-service teacher students perceived the InquiBiDT course as useful, they felt more competent than the students in the other courses and thus the pre-requisites for the implementation of similar approaches in their future teaching are given. Teaching attitudes did not differ between the students of all courses, which is contradictory to recent research.
One reason might for this finding might be the fact, that students were mainly satisfied in each course because of a high quality teaching in every case. Another reason might be the assessment of attitudes with a new instrument. It was pilot-tested, but large-scale validation is missing and further work to improve the scale is needed.

The interviews revealed the perception of a time consuming learning activity for all course students. Especially the InquiBiDT students with low technological affinity complained about the hints of wiki applications: Using wikis, Google Maps or other open source tools needs to be trained and if learners are not experienced to create digital content, these activities initially are not too effective. This aspect has to be considered if mobile technology is used for IBSE. Another interesting finding is that only the courses 2 and 3 requested more fieldwork, while the InquiBiDT students were satisfied with the amount of fieldwork. Some of the latter wish more faculty support during their field work activities. For future work it has to be considered, if this kind of support is provided for the first steps of self-determined learning fading it out during the IBSE activities.

In general, this pilot-study points towards the potential of the InquiBiDT approach to link IBSE to outdoor learning.

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