"Be bold and take a challenge": Could motivational strategies improve help-seeking?

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Abstract. We are exploring whether the use of facilities aimed at improving the learner's motivation has an effect on learning food-chains and food-webs, but also on help-seeking behaviour. The M-Ecolab is a Vygotskyan intelligent learning environment that incorporates both cognitive and affective feedback by combining a cognitive model capable of providing written feedback at the cognitive and meta-cognitive level and a model-driven, considerate more-able partner who gives spoken, affective feedback. A preliminary study of the effects of the M-Ecolab in learning was carried out in a real-class situation. The results showed that learners in the M-Ecolab had significantly greater learning in their post-test scores than students in the control condition in which affective feedback was not available. Moreover, in the M-Ecolab, engaged students (those having an above-average use of the motivating facilities) tended to look more effectively both for quality and quantity of help resulting in more fruitful interactions.

1. Introduction

Education is a complex activity involving the complementary factors of the learner's cognitive and affective states. What is needed for the design of systems are models and theories that integrate the various cognitive and affective components [1]. Research in cognitive science has provided the means to understand the learning process better [2], and shown that meta-cognition is a crucial aspect of learning [3]. One of the meta-cognitive strategies that seems to have a great impact in learning is help-seeking [4]. This paper addresses the issue of the student's state of motivation and its interaction with help-seeking. In particular our project focuses on the effects of motivational scaffolding in the M-Ecolab, a Vygotskyan learning system for teaching children concepts related to food-chains and webs that in earlier versions has shown the effectiveness of scaffolding the learner's activities based on cognitive and meta-cognitive models [5]. The M-Ecolab provides a test-bed for modelling and reacting to different motivational states and allows an investigation of its effects on learning. The mechanisms for modelling the motivational state consist of estimations of the learners' effort, independence and confidence in the learning activities during the interaction with the system. The results of an exploratory study suggest that strategies aimed at improving the learners' motivation do indeed have an effect on learning and, interestingly, further data analysis suggest that the student's help-seeking behaviour might be improved with the use these strategies.

2. Help-seeking

Help-seeking allows learners to manage academic problems by keeping them actively involved in the learning situation [6]. The importance of this particular learning strategy lies in the fact that it can create means to acquire skills or knowledge not only for immediate but also for future application. Nelson-Le Gall [4] argues that help-seeking is a social activity and it is in social contexts that learners find the motivation to ask for help and contribute with their knowledge to assist others. To understand help-seeking, Nelson-Le Gall [4, 7] proposed a Vygotskyan framework consisting of the following steps:

1. Become aware of the need of help
2. Decide to seek help
3. Identify potential helper(s)
4. Use strategies to elucidate help
5. Evaluate help-seeking episodes

Research in intelligent tutoring systems has led to the development of different means to offer learners the help they need in their interactions. However, despite its benefits help-seeking is not always used effectively by students in learning environments [7]. To overcome this deficiency researchers have focused on providing means to create in learners an awareness of their need for help, as it is believed that successful students continually evaluate, plan and regulate their own academic progress. This self-awareness of the learning process, or meta-cognition, is a pre-requisite for help-seeking to occur but is not in itself obvious to some learners. Systems such as the Ecolab II [5], have tackled this issue by providing help at the meta-level, aimed at making the learners more aware of their help-seeking needs. Another more comprehensive approach has been the creation of a help-seeking behaviour model implemented as a set of production rules [8]. This model aims at developing meta-cognitive awareness by providing the learners, via a help-seeking agent, with feedback about their use of the help facilities.

Even if help-seeking awareness is the cornerstone of successful help-seeking behaviour, more research is needed in tutoring systems as it might not be the only process involved in successful help-seek behaviour. Nelson Le-Gall's model presented above, includes four more steps beyond simply awareness of the need for help that also have an important effect on help-seeking behaviour. The importance of the remaining processes, particularly step number two, is crucial for a successful help-seeking behaviour [9]. Of relevance for our work is the fact that Nelson Le-Gall's model presupposes a social context where not only the participation of the learner and a more-able partner are required, but also the learners' believes in their competence (ability) and actions (effort). It would be interesting to find out whether by creating an explicit, considerate more-able partner who is able to alter its spoken feedback based on an underpinning motivational model, more fruitful interactions occur. In particular we are interested in whether by scaffolding motivation, learners could not only learn and be made aware of their help-seeking deficiency but also advance their help-seeking behaviour by praising or encouraging their effort and independence. This is a novel approach as the effect that affective scaffolding could have in learning, and help-seeking behaviour in particular, has not yet been addressed.

We think that it is important to expand our knowledge in this area and we present preliminary results of the effects of motivational scaffolding in learning and its relationship with help-seeking in tutoring systems. We argue that within a simulated social context, provided by a computerised more-able partner informed about the particular cognitive and affective needs of the learner, students can progress from awareness to evaluation as in the model above.

3. Motivational scaffolding in the M-Ecolab

To shed some light onto this issue we have developed the M-Ecolab, an extension of earlier Ecolab software. Previous evaluations of the Ecolab system have illustrated the benefits of challenging the student and guiding, but not controlling, her intellectual extension [10] and of offering the learners help at the meta-level by making low-ability learners more aware of their help-seeking needs [11]. The success of this software is thought to derive from modelling the learner's cognitive and meta-cognitive traits. By analysing the learner's ability and collaborative support actions with the tutoring system, the Ecolab software is capable of altering the interactions offering different degrees of help and suggesting different learning activities (from a total of ten) to individual learners. The Ecolab provides cognitive help at four levels, the higher the level the greater the control taken by the system and the less scope there is for the pupil to fail [12].

Our approach for motivational scaffolding revolves around three motivational traits identified as key in learning contexts: effort, confidence and independence from the tutor [13]. The rationale of the M-Ecolab is that an underpinning model of the learner's motivation can be built by assessing her actions with the system and by considering the learner's cognitive and meta-cognitive state and relating them to motivational variables. The M-Ecolab also reacts accordingly by offering motivating elements that vary according to the perceived cause of de-motivation. Since the original Ecolab was based on a Vygotskyan model, a social environment was simulated by incorporating on-screen characters. The motivational model was implemented so that motivating scaffolding is available during the interaction with the software via a button within the interface, and is the rationale for the characters' behaviour.

The motivating facilities in the M-Ecolab consist of spoken feedback given by a more-able partner, a character called Paul. Since the system maintains a motivational model of the learner, Paul is able to alter his voice tone and gestures according to the perceived state of de-motivation in order to encourage the learner: be it to put more effort, to be more independent or to become more confident. There exist two classes of spoken feedback: pre- and post-activity. Pre-activity feedback informs the learner of the objectives of that learning activity whereas post-activity feedback offers motivating scaffolding making the learner reflect on her behaviour. The learner can listen to the spoken feedback as many times as she wants via a button on the interface. Additionally a quiz has been integrated as a motivating facility, but its activation depends on the learner and not on the underpinning motivational model. If activated, the quiz asks questions related to the food-chains topic. Wrong answers are not corrected but an indicator shows the number of correct and incorrect answers that the learner has tried-out during the interaction. Right answers are praised but a maximum of three correct answers is allowed per activity in order to avoid the learner to concentrate on the quiz more than the learning activity.

3.1 Ada and the M-Ecolab.

The following scenario illustrates a typical interaction with M-Ecolab:

Ada is a 10 year-old student who has not completed the 'Energy' activity in the M-Ecolab, but has attempted various eating actions without positive results. Ada then decides to choose a new activity. She clicks on the 'New Activity' button and a character appears introducing herself as Mrs. Johnson who tells Ada what the Ecolab is and what she is expected to do. To make things interesting, Mrs. Johnson prompts Ada to find what is inside a treasure-chest that can only be opened once she has collected the letters of a password.

Mrs. Johnson introduces Paul, who is a child from another school that has been successful in doing the Ecolab before. Paul then states the learning objectives for that particular activity (see Fig. 1). From now on a new button called 'Treasure Chest' appears on the interface. Ada clicks on the new button and discovers the empty password, the treasure chest and two buttons, one to call Paul and another to solve a quiz. She clicks on the Paul button causing Paul to repeat the learning objectives which direct her to the accompanying booklet. After having read the appropriate page of the booklet, Ada does correct and incorrect actions. Ada then notices a green tick appearing next to the 'Activity button' indicating that she has completed the activity. She decides to click on the 'Activities' button and Paul appears praising her efforts but stating that in the future she needs to ask for less help when she makes an error. Three models of her interaction are being created: a cognitive, a meta-cognitive and a motivational. According to the meta-cognitive model, the M-Ecolab suggests 'Go on, learn about something new and the Ecolab will help you. Click on the activity that you want to do next:'. Ada selects a new activity called 'Food 1'. A dialogue box appears with three choices of challenge and a suggestion 'Be bold and take on a challenge'. Ada chooses challenge level 2 and then Paul, based on the motivational model states the objectives for that activity followed by a dialogue box indicating Ada to go to the booklet. She then continues working on the system, building more eating relationships, until she notices the green tick next to the 'Activities' button, indicating she has finished this activity. Once again she clicks on the 'Activities' button but this time Paul does not appear, as the motivational model believes she does not need more affective feedback. Ada continues with the activity called 'Feeding 1' creating more food-chains.

Fig. 1 An explicit more-able partner for the M-Ecolab

While Ada completes actions in the M-Ecolab, the system updates its three learner models: cognitive, meta-cognitive and motivational. These models consist of beliefs about how much she understands eating relationships, how much it believes she understands her own learning needs related to help-seeking, and also how much it believes she needs affective feedback. This information is used to adjust the affective post-activity feedback provided by the system according to the perceived degree of motivation, and to select the appropriate motivational trait that will be supported [13], prompting the character to alter his voice tone and gestures accordingly.

4. Preliminary evaluation of the M-Ecolab

To throw some light onto the issue of the influence of motivational scaffolding in the learner's behaviour, an exploratory study of the effects of the M-Ecolab was conducted in a local primary school at the end of the academic year 2003-2004. We measured the students'

learning with the M-Ecolab using the same pre- and post-tests as in previous Ecolab evaluations [11]; the questions used in the learning tests were different from those of the quiz. The learners' motivation was assessed with an adaptation of Harter's test [14]. The participants were members of two fifth grade classes aged between 9-10. There were 10 students in the control condition, 5 girls and 5 boys and 19 learners in the experimental condition, 9 girls and 10 boys. All the students had been introduced to food-chains and food-webs prior to the study. The students were asked to complete a pre-test for 15 minutes and then a five-minute motivational questionnaire. Assistance was provided to the students who requested help to read the questions. Two weeks later, the M-Ecolab was demonstrated with the use of a video-clip showing its functionality. It was at this point that the researcher answered questions regarding the use of the software. One tablet PC was provided for each learner, with the appropriate version of the software (control = Ecolab, experimental = M-Ecolab). The students were then allowed to interact with it for 30 minutes. Immediately after the interactions, the pupils were asked to complete a post-test. Four weeks after the interaction the students were asked to complete a delayed post-test.

5. Results

This preliminary study looked at the effect that the two conditions had in increasing the student's learning in the Ecolab. To ensure that both conditions had a comparable level of knowledge about food-chains and food-webs, a t-test on the means of the pre-test was carried out showing a non-significant difference, see Fig. 2. In order to assess the overall learning gain in the M-Ecolab an analysis of covariance (ANCOVA) on the post- and delayed post-test data with three covariates: ability, motivation and performance on the pre-tests, indicates that the difference between the control and experimental groups is significant for both the post- and delayed post-test (post-test: $F_{(4,28)} = 9.013$, $p<.001$; delayed post-test: $F_{(4,27)}=4.0, p<.02$), see Fig. 2.
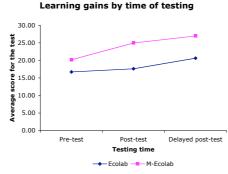

Fig. 2 Learning gains by time of testing

5.1 Motivation in the M-Ecolab

Motivation was assessed at two points during the study: the first time, during the pre-test using an adaptation of Harter's test [14] and the second, during the interaction using the underpinning motivational model embedded in the M-Ecolab [13]. Students having a below-average motivation according to Harter's tests were catalogued as less motivated. An analysis to contrast the learning gains in learners with low motivation between the two conditions was done with t-tests on the post-test's means. The results showed that learners with less motivation in the experimental condition yielded better learning than less motivated learners in the control group ($t(13)= -2.280$, $p <. 05$).

The underpinning motivational model in the M-Ecolab assesses motivation during the interaction using three motivational variables: effort, independence and confidence. A between-subjects analysis was carried out to assess the differences for the motivational variables within the two conditions. The results showed that there was not a significant difference in confidence or effort, but there was a significant difference in the independence values (t(25) = 2.069, p < .05) suggesting a greater independence for students in the control condition. These results were intriguing as it was expected that independent learners had gone beyond their intellectual capacities in the ZPD; however, judging from the findings in the post-test scores, it was clear that independence did not yield better learning outcomes in the Ecolab condition.

5.2 Help-seeking in the M-Ecolab

In order to deepen the analysis of independence, an examination of the type of help that learners had during their interactions was undertaken. In the M-Ecolab, less-independent students had greater degrees of help and showed lower effort in individual activities during the interaction with the system. Less independent students were more likely to be found in the experimental group (n=11) than in the control group (n=2). However, despite being less independent, students in the experimental group were more successful in their pre-, post-test learning gain as revealed by a within-subjects test (t(18) = -3.815, p < .01). To throw more light on the aspect of help that accounted for these learning gains, an analysis of help-seeking was undertaken distinguishing quantity from quality of help and trying to understand the nature of collaborative support requested by the students:

- Participants having an above-average quantity of help, whether provided by the software or requested by the student, were catalogued as having "lots" of help, otherwise as having "little" help.
- The mean level of help was calculated for all the participants, if learners received an average level of help greater than the group's mean, more quality of help, they were considered to have "deep" help or "shallow" otherwise.

Results indicated that students in the M-Ecolab condition who had little help (less quantity) increased their learning from the pre- to the post-test (t(9)=-3.381,p<.01). Moreover, participants requesting for deep help (more quality) in the M-Ecolab condition accounted for better performance in a within-subjects design (t(8)=-4.239,p<.01) than those in the control group. These results suggest that in M-Ecolab quality rather than quantity of help accounts for a greater impact in learning. A further between-subjects analysis of the differences in the means in the post-test scores for students using deep help (see Table 1) shows that there is a significant different between the two conditions (t(16)=-2.5443, p<.05), suggesting better learning experiences in the M-Ecolab. Table 1 also shows that the mean values for quality (with values ranging from one to four) and quantity of help (measured through the number of clicks on the help button) were greater for the M-Ecolab condition, albeit not significantly, suggesting that the effect of motivating facilities prompted the learners to request for more quality and quantity of help.

	Quality of help (mean level of help requested)	Quantity of help (clicks on help button)	Mean post-test scores
M-Ecolab (n=10)	3.12	17.50	24.70
Ecolab (n=7)	3.03	1186	18.86

Table 1. Mean values for students requesting deep help.

In order to have an insight into the role of the motivating facilities provided by the M-Ecolab, participants having an above-average request for motivating facilities were catalogued as "engaged". The results of a paired-samples test indicated that engaged students in the M-Ecolab accounted for a greater learning from the pre- to the post-test (t(8) = -4.807, p < .01), but not the disengaged students. Although there is not a significant difference in learning when comparing the post-test between the engaged and disengaged groups, the evidence suggest that better learning outcomes occurred when more quality of help was selected, replicating previous findings [5]. However, the evidence also suggests that there is a tendency in the experimental group, particularly among engaged students, to look for a greater quality of help, although this result is not significant (t(16) = -1.934, p = .071).

6. Discussion and conclusions

This exploratory study has presented evidence that motivating facilities might improve help-seeking behaviour in the M-Ecolab. The results suggest that learners using the M-Ecolab had more learning gains in both, post- and delayed post-tests than those in the control group. The M-Ecolab is a Vygotskyan system whose aim is to develop the learners' ZPD [15] implying, among other things, a more independent behaviour on the part of the learners. An analysis of the motivational variables that make-up the underpinning motivational model suggested that the motivational variable with greater differences across conditions was independence, being the students in the M-Ecolab less independent and at the same time more successful in their post-test scores. This finding was intriguing as it was expected that a more independent behaviour could lead to greater learning gain. As in M-Ecolab independence is modelled in terms the cognitive model's belief about the learners' need of help, the lack of independence (the need of more help) prompts the system to provide motivating feedback aimed at creating awareness about help-seeking.

A further analysis of the help-seeking behaviour showed that, in correspondence with previous evaluations, it was the learners who asked for greater quality of help rather than just more help those who achieved better learning outcomes. The evidence suggests that within the experimental condition, learners making more use of the motivating facilities were also those requesting higher quality of help. The findings of earlier Ecolab evaluations [11] highlighted the importance of providing the learner with challenging activities but also of offering help at the meta-level, so making the learners more aware of their help-seeking needs, which is consistent with the process of teaching within the ZPD [15]. This is also valid in the M-Ecolab but now it also seems that by having an explicit more-able partner learners, particularly those seeking the more-able partner's assistance, seemed to engage in more fruitful interactions. It also seems that the factor prompting the learners to ask for the help they need is the presence of the motivating facilities, as it was engaged students who improved their learning most.

It is recognised that there were two main problems with this pilot study. The first was the small number of participants; the second was the limited amount of time that was allowed for the interaction. With longer interaction time a richer analysis could be made of the effects of the more-able partner in the learning process, ruling-out the possibility of the 'novelty effect' that the motivating facilities could create in short interactions. If motivation goes beyond the novelty effect, longer interactions could improve an incipient collaborative setting between the learner and Paul. If Paul, who is already able to change his tone of voice, could also able to alter his facial expressions the feedback provided by him could create more productive interactions. With longer interactions times it could be possible to elucidate whether the pupils do pay more attention to Paul and ultimately decided to follow

his advice. Future evaluation will overcome these shortcomings and also reveal whether an adaptive model that does not present motivating facilities if they are not necessary will work as well for all ability pupils. Work also needs to be done to find a relationship between meta-cognition and the various traits that affect motivation, particularly confidence, as Tobias and Everson [16] suggest that it is likely that high displays of meta-cognition reduce anxiety, hence increasing confidence. There are more possibilities open beyond the current investigation, such as making Paul say the feedback at the meta-level. By doing so it might be possible to investigate whether the learner advances through more steps in Nelson-Legall's model [4]. It would be interesting to define and further explore, how increases in help-seeking capability in the learner improves learning.

Acknowledgments

References

[1]   Pintrich, P.R. and T. Garcia, *Student goal orientation and self-regulation in the college classroom.* Advances in Motivation and Achievement, 1991. **7**: p. 371-402.

[2]   Lajoie, S.P. and S.J. Derry, *Computers as cognitive tools.* 1993, Hillsdale, NJ: Lawrence Erlbaum Associates.

[3]   Flavell, J.H., *Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry.* American Psychologist, 1979. **34**: p. 906-911.

[4]   Nelson-Le Gall, S., *Help-seeking: An understudied problem solving skill in children.* Developmental Review, 1981. **1**: p. 224-246.

[5]   Hammerton, L. and R. Luckin. *How to help? Investigating children's opinions on help.* in *10th International Conference on Artificial Intelligence in Education.* 2001. San Antonio, TX: St Mary's University, p. 22-33.

[6]   Nelson-Le Gall, S. and L. Resnich, *Help seeking, achievement motivation and the social practice of intelligence in school*, in *Strategic help-seeking. Implications for learning and teaching*, S.A. Karabenick, Editor. 1998, Lawrence Erlbaum Associates, Inc.: London.

[7]   Aleven, V., et al., *Help Seeking and Help Design in Interactive Learning Environments.* Review of Educational Research, 2001. **73**(2): p. 277-320.

[8]   Aleven, V., et al. *Toward tutoring help seeking.* in *Seventh International Conference on Intelligent Tutoring Systems, ITS 2004.* 2004. Brasil: Spring Verlag, p. 237-239.

[9]   Ryan, A.M. and P.R. Pintrich, *Achievement and social motivational influences on help seeking in the classroom.*, in *Strategic help seeking. Implications for learning and teaching*, K. S.A., Editor. 1998, Earlbaum: Mahwah. p. 117-139.

[10]   Luckin, R., ´Ecolab´: Explorations in the Zone of Proximal Development, PhD Thesis, in *School of Cognitive & Computer Sciences, University of Sussex.* 1998, University of Sussex: Brighton, BN1 9QH.

[11]   Luckin, R. and L. Hammerton, *Getting to know me: helping learners understand their own learning needs through Metacognitive scaffolding*, in *Proceedings of the sixth Conference on Intelligent Tutoring Systems.* 2002, Berlin : Springer: Biarritz, France.

[12]   Wood, D.J. and H.A. Wood, *An experimental evaluation of four face to face teaching strategies.* International Journal of Behavioural Development, 1978. **1**: p. 131-147.

[13]   Rebolledo, G. *Motivational Modelling in a Vygotskyan ITS.* in *Artificial Intelligence in Education.* 2003. Sydney, Australia: IOS Press, p. 537-538.

[14]   Harter, S., *A new self report scale of intrinsic versus extrinsic orientation in the classroom: motivational and informational components.* Developmental Psychology, 1981. **17**(3): p. 300-312.

[15]   Vygotsky, L.S., *Mind in society : The development of higher psychological processes.* 1978, Cambridge, MA: Harvard University Press.

[16]   Tobias, S. and H.T. Everson, *Knowing what you know and what you don´t: further research on metacognitive knowledge monitoring.* 2002, College Entrance Examination Board: New York. p. 25.