Influence of mood and curiosity on mental effort and learning performance during problem solving in adaptive learning

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Abstract
In the context of adaptive learning designs, we are interested in gaining insight into the influence that mood and curiosity exert on effort and performance. The influence of mood on executive functions is explained best with the mood-as-information theory. Mood is linked to curiosity, which can be seen as a kind of intrinsic motivation. Epistemic curiosity manifests the desire for new information and learning. Students of an adaptive course were recommended to either solve a step-by-step task or a one-step task. The result of that task then determined the difficulty of the following one and so on. Before each task, students answered questions about mood and curiosity and after each task, they reported on mood and mental effort associated with each task (intrinsic cognitive load). The 81 participants – mostly male (99%) industrial engineer students with a mean age of 30 - were part of an applied sciences course. The path model that resulted from the analyses had a good fit. Type of task (one-step; step-by-step) was a moderator for the model. Generally, better mood led to more mental effort (cognitive load). Higher task scores and curiosity led to better mood after task execution. Solving the more difficult one-step tasks had the effect that besides mood, curiosity also led to more mental effort, which in turn resulted in slightly lower task scores. This corresponds to the “mood as cognitive load” theory. Missing these effects for the step-by-step tasks could be an indication that the used adaptive learning design works well.

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Introduction
Our research team creates and evaluates adaptive learning designs. In this context, we are interested in the influence that affective and cognitive states exert on learning performance. The research question of our paper is ‘What influence do mood and curiosity have on effort and performance in an adaptive learning course?’ Emotions and mood play important roles during learning. This has been reported since at least the early nineties (e.g. Pekrun, 1992; Boekaerts, 2011; Park, Plass, & Brünken, 2014).
Moods are coherent affective states that last minutes or hours, unlike emotions, which can last seconds or fractions of seconds (Lazarus, 1994). Mitchell and Phillips (2007) reviewed the influence of positive and negative mood on executive functions and found that research results were explained best with the mood-as-information theory. According to this theory, positive mood most likely results in heuristic processing while negative mood leads to in analytic processing. They discuss two other theories: “mood as cognitive load” theory, and “positive-mood-as-a-facilitator” theory.
Motivational factors, such as novelty or task appeal, might influence mood effects, resulting in better performance when mood is positive. That way, mood is linked to curiosity as "a particular system of intrinsic motivation that drives agents to learn” (Gottlieb, Lopes, & Oudeyer, 2016).
Although curiosity also applies to situations outside the educational setting (e.g. interpersonal curiosity), in this paper we only focus on curiosity as an educational construct, referring to it as epistemic curiosity. Epistemic curiosity denotes the “desire for new information that motivates exploratory behaviour and knowledge acquisition” (Berlyne, 1954, cited by Litman,

Hutchins, & Russon, 2005). It can be understood as “cognitive curiosity” or “cognitive motivations” (Richards, Litman, & Roberts, 2014) and is comprised of an individual component (trait) and a situational component (state). Although the definition of curiosity already implies that it promotes learning, empirical evidence on such effects is scarce and inconsistent at best (e.g., Jaen, & Baccay, 2016; Kang, Hsu, Krajbich, Loewenstein, McClure, et al., 2009).

Method

This study was part of the evaluation of an adaptive course on Moodle (Ver 3.2). Students took a prior knowledge test and based on their results, they were recommended to either solve a step-by-step task (for beginners) or a one-step task (for experts). In turn, the result of that task then determined the difficulty of the following one and so on. The step-by-step task included hints for every step of the task as well as explanations in case of incorrect answers. In the one-step tasks, the students were supposed to solve the task without receiving any hints. Bevor each task, the students answered a question about their current mood (good to bad mood; 5-point-Likert scale) and their boredom/curiosity regarding the task they were about to solve (bored to curious; 5-point-Likert scale). After each task, the students answered the same mood-related question in addition to a self-evaluation of the strength of the mental effort they felt was needed to solve the task (i.e. their intrinsic cognitive load; 7-point-Likert scale). The students were allowed to repeat every task as many times as they wanted to. In these analyses we used the first trials only. The 99% male sample consisted of 107 students out of seven classes of an applied natural sciences course (physics) for industrial engineers with a mean age of 30 (standard deviation of 5). 26 students did not perform any task or left before the semester began, reducing the sample to 81 students. During the semester, the students completed 917 tasks (repetitions not included, which amounted to 424), 417 of which were one-step tasks and 500 were step-by-step tasks. The statistical analyses were conducted with AMOS 22, calculating an exploratory path model to find the interrelations between mood, curiosity, mental effort and task performance.

Results

The resulting path model had a good fit with a cmin/df relation of 1.63 (p=.196). All other fit measures were above the recommended values (NFI=.99; TFI=.96; IFI=.99; TLI=.99; CFI=.99), and the RMSEA was .028 (close=.673). Type of task (one-step; step-by-step) was a moderator for the model. For both task types, the afore-measured mood had an influence on mood after task execution (one-step: .37; step-by-step: .49), and on mental effort (one-step: .29; step-by-step: .44). Curiosity (one-step: .27; step-by-step: .14) and task score (one-step: .30; step-by-step: .30) exerted an influence on mood after task execution. In the path model including only difficult tasks, i.e. the one-step tasks, we found influences of afore-measured mood on task score (.15), curiosity on mental effort (.22) and mental effort on task score (-.16).

Discussion and Conclusion

In general, better mood led to more mental effort, i.e. a higher cognitive load. Higher task scores and curiosity led to better mood after task execution. Solving the more difficult one-step tasks had the effect that besides mood, curiosity also led to more mental effort, which in turn resulted in slightly lower task scores. Following the paper of Mitchell et al., (2007), these results are consistent with the “mood as cognitive load” theory, which postulates that positive and negative affect impair task performance due to higher cognitive load (i.e. higher mental effort), especially with tasks that require more resources. The circumstance that good mood led to slightly higher task scores corresponds to the “positive-mood-as-a-facilitator” theory. For the step-by-step tasks, we found neither indirect effects of curiosity nor direct effects of mental effort on performance. This could indicate that the adaptive learning design we used works as demonstrated by Imhof, Bergamin, Moser & Holthaus (2018), i.e. the learning design decreases cognitive load.

References

- Berlyne, D. E. (1954). A theory of human curiosity. *British Journal of Psychology, 45*(3), 180±191.
- Boekaerts, M. (2011). Emotions, emotion regulation, and self-regulation of learning. *Handbook of self-regulation of learning and performance*, 408-425.
- Fraser, K., Ma, I., Teteris, E., Baxter, H., Wright, B., & McLaughlin, K. (2012). Emotion, cognitive load and learning outcomes during simulation training. *Medical education*, *46*(11), 1055-1062.
- Gabel, M. S., & McAuley, T. (2018). Does mood help or hinder executive functions? Reactivity may be the key. *Personality and Individual Differences*, *128*, 94-99.
- Gottlieb, J., Lopes, M., & Oudeyer, P. Y. (2016). Motivated cognition: Neural and computational mechanisms of curiosity, attention, and intrinsic motivation. In *Recent Developments in Neuroscience Research on Human Motivation* (pp. 149-172). Emerald Group Publishing Limited.
- Imhof, C., Bergamin, P., Moser, I., & Holthaus, M. (2018). Implementation of an adaptive instructional design for a physics module in a learning management system. *CELDA 2018 - 15th International Conference on Cognition and Exploratory Learning in Digital Age 2018* (pp. 68-78). 21th to 23th Octobre 2018, Budapest, Hungary.
- Jaen, M.C.A, & Baccay, E.S. (2016). Curiosity, Motivation, Attitude, Gender, and Mathematics Performance. *The Normal Lights*, 10(2), 98-103.
- Kang, M. J., Hsu, M., Krajbich, I. M., Loewenstein, G., McClure, S. M., Wang, J. T., & Camerer, C. F. (2009). The wick in the candle of learning: Epistemic curiosity activates reward circuitry and enhances memory. *Psychological Science, 20*(8), 963–973.
- Lazarus, R. (1994). The stable and unstable in emotion. In P. Ekman, & R. J.Davidson (Eds.), *The nature of emotion*. New York: Oxford University Press.
- Litman, J., Hutchins, T., & Russon, R. (2005). Epistemic curiosity, feeling-of-knowing, and exploratory behaviour. *Cognition & Emotion*, *19*(4), 559-582.
- Martin, E. A., & Kerns, J. G. (2011). The influence of positive mood on different aspects of cognitive control. *Cognition and Emotion*, *25*(2), 265-279.
- Mitchell, R. L., & Phillips, L. H. (2007). The psychological, neurochemical and functional neuroanatomical mediators of the effects of positive and negative mood on executive functions. *Neuropsychologia*, *45*(4), 617-629.
- Park, B., Plass, J. L., & Brünken, R. (2014). Cognitive and affective processes in multimedia learning. *Learning and Instruction 29*(1), 125–127.
- Pekrun, R. (1992). The impact of emotions on learning and achievement: Towards a theory of cognitive/motivational mediators. *Applied Psychology*, *41*(4), 359-376.
- Richards, J. B., Litman, J., & Roberts, D. H. (2014). Performance characteristics of measurement instruments of epistemic curiosity in third-year medical students. *Medical Science Educator*, *23*(3), 355–363.

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Background and Research Question

United Nations Educational, Scientific and Cultural Organization

UNESCO Chair on Personalized and Adaptive Distance Education at the Swiss Distance University of Applied Sciences, Brig, Switzerland

LEARN MOOD on

What influence do mood and curiosity have on effort and performance in an adaptive learning course?




Theoretical Background

- Mood and emotions
- Epistemic curiosity (cognitive curiosity)
  - “desire for new information that motivates exploratory behaviour and knowledge acquisition”

- Motivational factors (as novelty and task appeal) links mood to curiosity: mood as a particular system of intrinsic motivation that drives agents to learn (Gottlieb, Lopes, & Oudeyer, 2016)

- mood-as-information theory
- mood as cognitive load theory
- positive-mood-as-a-facilitator theory

Adaptive Instruction Design

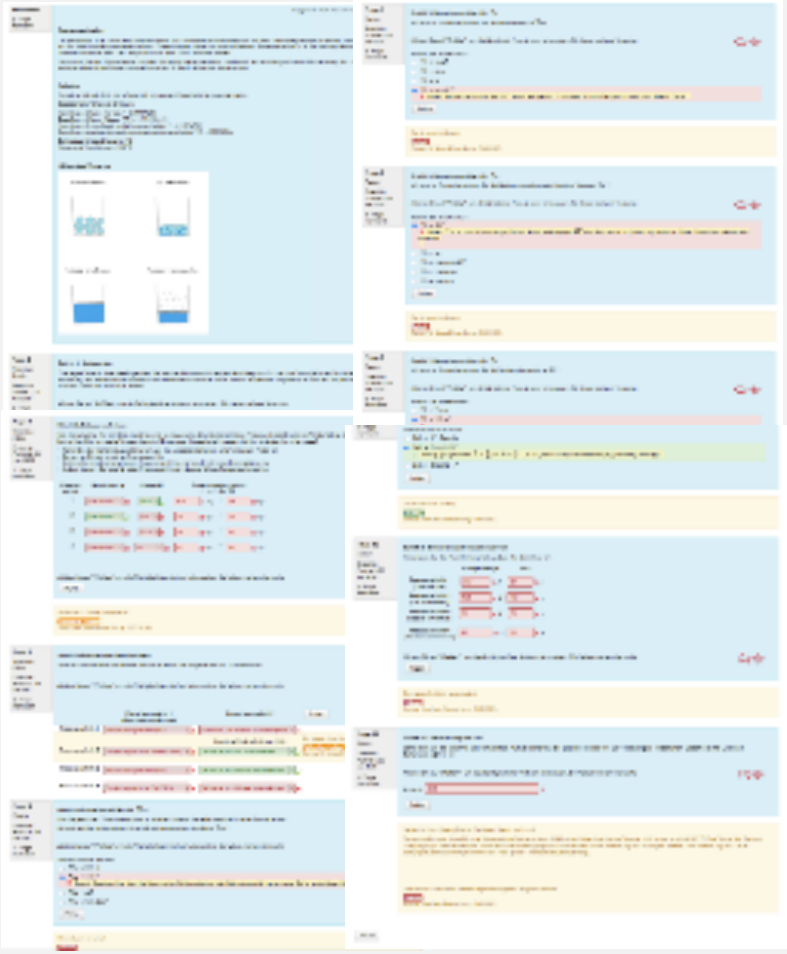
- Personalization and adaptation
  - With pre-knowledge (personalization) and responses to tasks and sub-tasks (adaptation)
- Guided instruction (step-by-step) vs. unguided instruction (one-step)

- Bevor and after each each task
  - current mood
  - Bored/curious
- After each task
  - Mental effort (i.e. intrinsic cognitive load)
- Students could repeat task
  - In analyses we used the first trials only

Adaptive Instruction Design

High performer

Low performer



Adaptation model
Adjustment of task difficulty (cognitive load) through:

guided instruction
(more feedback and learning aids)
+
unguided instruction

Method

Sample

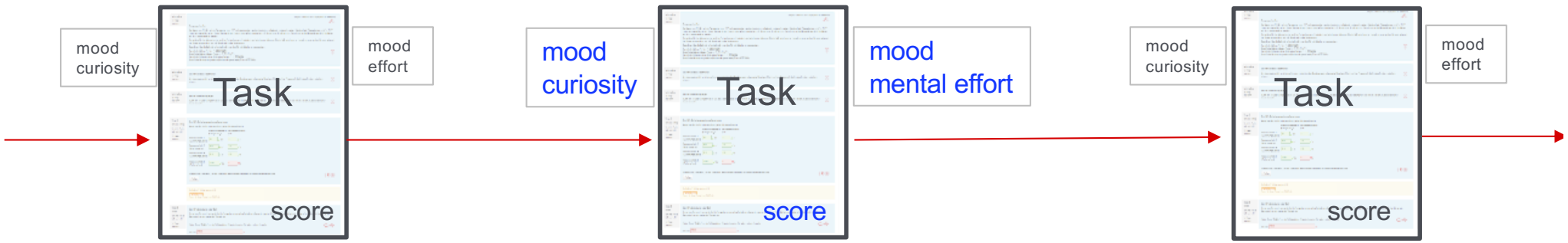
- 107 industrial engineers students; 7 classes in physics
  - 99% male
  - Mean age 30 years (SD 5)

- **81 students** performed some tasks (26 did no task)
  - 417 one-step / unguided tasks
  - 500 step-by-step / guided tasks

Method

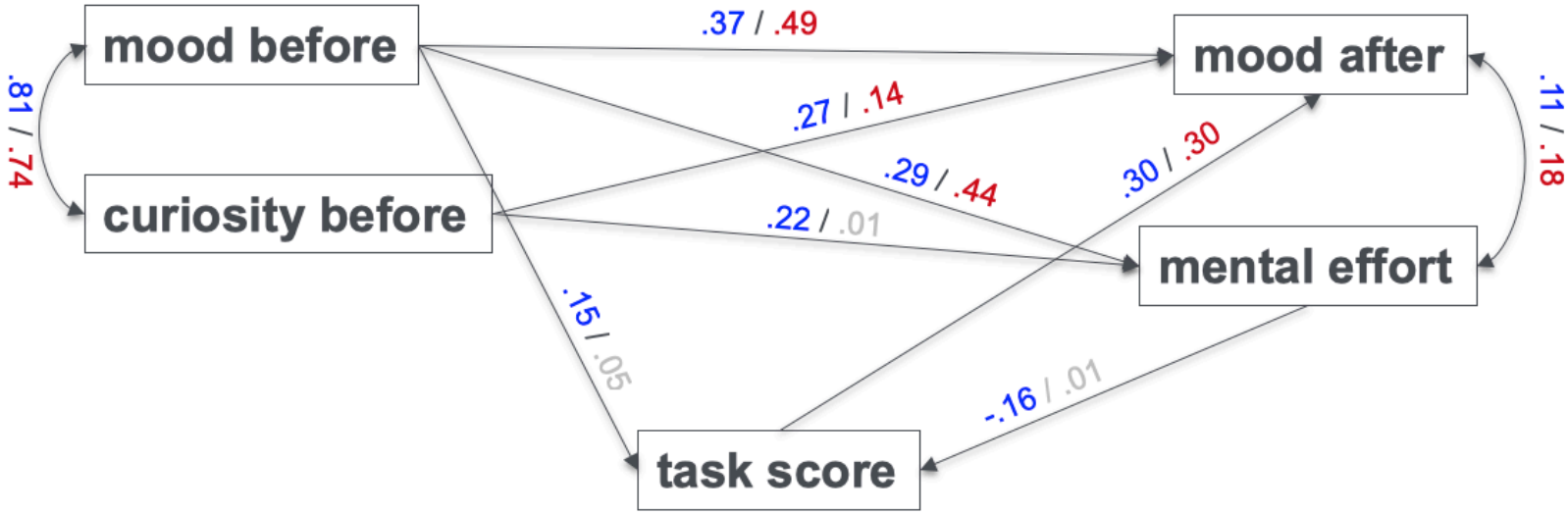
Research Design

- Personalization (pre-knowledge test)
- 417 unguided (one-step) and 500 guided (step-by-step) tasks



Results

unguided instruction / guided instruction



Model Fit

- cmin/df = 1.63; p=.196
- NFI = .99; TFI = .96; IFI = .99; TLI = .99; CFI = .99
- RMSEA = .028; pclose = .673

Discussion

Difficult one-step / unguided tasks

- Positive mood and more curiosity led to more mental effort
  - That is consistent with the “mood as cognitive load” theory (Mitchell et al., 2007)

- Positive mood let to slightly better performance
  - corresponds to the “positive-mood-as-a-facilitator” theory

- More mental effort resulted in slightly lower performance

Step-by-step / guided tasks

- no effects of curiosity on mental effort and performance
- no effects of mental effort on performance

Conclusions

- The missing effect of mood, curiosity and of mental effort on performance
  when working with the guided easier step-by-step tasks

➢ could indicate that our adaptive learning design works
as demonstrated by Imhof, Bergamin, Moser & Holthaus (2018)

i.e. the learning design decreases cognitive load

and seems to reduce the influence of mood and curiosity on mental effort (cognitive load) and performance

Limitations and future

Limitations

- Self-reports during learning task
  - Interference with learning task
  - Too many self-reports (before and after each task) -> may provoke anger

Future

- Estimating mood, curiosity and other emotions with non-intrusive methods
  - Log files
  - Mouse tracking
  - Text analyses

Thank you

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