Students' basic psychological needs satisfaction at the interface level of a computer-supported collaborative learning tool

Eyad Hakami [0000-0002-9742-105X], Khadija El Aadmi-Laamech, Lubna Hakami [0000-0002-7370-8072], Patricia Santos [0000-0002-7337-2388], Davinia Hernández-Leo [0000-0003-0548-7455], Ishari Amarasinghe [0000-0003-2960-4804]

Universitat Pompeu Fabra, Barcelona, Spain
{eyad.hakami01; lubna.hakami01}@estudiant.upf.edu
{khadija.elaadmi; davinia.hernandez-leo; patricia.santos; ishari.amarasinghe}@upf.edu

Abstract. Well-being has been considered an urgent vein of discussion in fields that intersect with Information and Communication Technologies. In this paper, we used a questionnaire adapted from the METUX (Motivation, Engagement, and Thriving in User Experience) model to explore how well a Computer-Supported Collaborative Learning (CSCL) tool's interface satisfy users' needs for competence, autonomy, and relatedness; and to test the instrument's validity in a CSCL context. METUX provides scales grounded in Self-Determination Theory (SDT) allowing researchers to foster insights into how technology designs support or undermine psychological needs, boosting user well-being. 53 bachelor students represented the tool's users based on convenience sampling. Our findings showed that users may not perceive the autonomy construct in the tools' interface, taking a neutral stance toward aspects of competence and relatedness as well. The results indicate the need for design interventions to improve the interface's ease of use, and the components that facilitate interaction and feelings of being connected. Regarding the instrument, more work is needed to validate the use of METUX interface in CSCL, especially for the autonomy subscale. Also, more scales from METUX (e.g., adoption and task spheres of experience) are needed to be included in the future for a fuller validation.

Keywords: Well-being, Computer-Supported Collaborative Learning, Self-Determination Theory, METUX

1 Introduction

The satisfaction of three basic psychological needs—*competence* (the sense of being capable and effective), *autonom*y (feeling self-governed and self-endorsed) and *relatedness* (feeling connected and interacting)— has been shown to be critical to both motivation and well-being in the field of psychology [1]. According to the Self-Determination Theory (SDT) [2], the satisfaction of these three needs is a universal prerequisite for psychological well-being. SDT theorists [2, 3, 4, 5] consider these needs as broad motivational inclinations that function throughout life domains and argue that satisfaction of all three needs, as opposed to only one or two, is crucial for well-being [6]. In education, SDT posits that students' intrinsic motivation is rooted in

having their basic psychological needs met [3]. Students are actively motivated to engage in learning tasks when pedagogical design appropriately satisfies these psychological needs [7]. The majority of SDT studies in this regard have investigated how the three needs are fulfilled in traditional face-to-face learning [8, 9], with some exceptions discussing SDT in online and digital learning contexts [7, 10]. One current direction of SDT research concerns the potential and challenges associated with the use of technologies in education [11]. More SDT research, according to [11], will undoubtedly be looking at not only how technology-enhanced learning can be designed to motivate engagement and learning [12], but also how teachers and students can be motivated to embrace technology as a tool for learning [13, 14]. In collaborative learning, sense of relatedness is particularly relevant due to the great amount of social interaction involved in collaborative settings. For example, a study by [15] showed that students' sense of relatedness to peers and teachers predicted their engagement level in collaborative writing using wikis.

The past decade has seen a rise in interest in human-centred design, where scholars and practitioners alike have struggled to translate the desire to design for human flourishing and well-being into clear and practical practice. The three basic needs can be utilised as inspirations or parameters to evaluate and enhance a design [13, 16]. Designing with users' psychological needs in mind (i.e., their desire to feel competent and autonomous, as well as their need to feel connected to others) is a key component of the SDT approach [13]. The notion of needs satisfaction implies that designers are required to understand users' expectations regarding the needs and adjust the design to meet those expectations [13]. For example, [17] applied SDT to understand what the three psychological needs entail in conversational agents' experiences. That study obtained insights into users' perceptions and expectations on the three needs, enabling the development of informative recommendations for fulfilling the needs in the design of conversational agents [17].

In this paper, we apply METUX TENS-Interface [13], a measure driven from SDT-based questionnaires, to explore students' perceptions on the extent to which their basic psychological needs are satisfied at the interface level of using PyramidApp, a computer-supported collaborative learning (CSCL) tool. PyramidApp is a web-based tool that enables teachers to design and implement CSCL scripts based on the Pyramid pattern [18]. Within the tool, students engage in collaboration following a Pyramid structure. Students are automatically allocated into small groups first and later into larger groups, facilitating them to reach a consensus to the given task at the end of the script. A teacher-facing dashboard is built into the tool to support teachers in orchestrating collaboration [19]. This work aims at exploring whether the three basic psychological needs are covered by the tool; and validating the used instrument in the tool's context for the purposes of continuous data collection and evaluation. We posit that the use of METUX TENS-Interface questionnaire in CSCL can provide meaningful insights about user autonomy, competence and relatedness; and therefore, inform the design processes in these regards.

The rest of this paper is organised as follows: We review the research context and the studied tool. Then we clarify the methods followed in this research, explaining the previous work and METUX model with a focus on the TENS-Interface questionnaire. Then we test the scales' validity, visualise and discuss the findings and conclude the paper by describing the implications of design and the future direction of this work.

2 Research context

2.1 Self-determination theory (SDT)

Self-determination theory (SDT) posits that basic psychological needs for autonomy, competence, and relatedness must be satisfied for an individual, at all ages, to develop a sense of growth, integrity, and well-being [4, 20]. Experiencing the feeling of effectiveness and mastery is central to the concept of competence. As one effectively completes tasks and encounters opportunities to apply skills and knowledge, this need is fulfilled. Feelings of inefficiency and failure are common responses to competence frustration. Autonomy is the experience of voluntary action, and is satisfied when one's behaviours, thoughts, and feelings are self-endorsed and authentic. When frustrated, one feels pressure, conflict, and being pushed in an undesired direction. Relatedness is the experience of bonding and care, and it is satisfied by feeling connected to others. Relatedness frustration comes with a feeling of being socially isolated and excluded [see 1, 2, 3, 4, 5, 20]. There is sufficient evidence from SDT [21, 22, 23] that a learning environment that satisfies students' need for autonomy, competence, and relatedness is essential for learners' self-determination and self-regulation. Students' intrinsic motivation, autonomous self-regulation, along with the quality of their performance, are influenced by the extent to which their basic psychological needs are satisfied in their learning environments [1, 4].

2.2 Pyramid pattern based CSCL Activities

Computer-Supported Collaborative Learning (CSCL) is an interdisciplinary field of research that aims to investigate how learners engage in collaboration with the help of computers [24]. Although CSCL provides opportunities to connect peers with the use of computers, there is no guarantee that every CSCL situation may create opportunities for productive interactions and therefore learning. To this end, scripts had been proposed as a way to structure collaboration by providing guidance and instructions to students on how to interact during collaboration in Technology Enhanced Learning scenarios [25, 26]. These 'scripts' are known as Collaborative Flow Patterns (CLFPs). Some of the well-known examples of CLFPs include Pyramid, Jigsaw, Think-Pair-Share (TPS), and Thinking Aloud Pair Problem Solving (TAPPS) [27].

Different CLFPs are shaped by the pedagogical rationale and constraints defined by CLFPs themselves [28]. For instance, Pyramid CLFP integrates activities occurring at multiple social levels. First learners will study a given problem individually to propose an initial solution. Learners then join in small groups, usually in pairs to discuss their solutions, and to propose a shared solution at the small group level. The discussion and negotiation will repeat in growing sizes of groups following a Pyramid structure until the whole group reaches a common solution to the given problem. Structuring collaboration according to this pattern provides several educational benefits to students. For instance, it provides equal opportunities for students to express their solutions, to negotiate with their peers, and also as the interactions accumulate across Pyramid levels it promotes positive interdependence. In this study, a tool called PyramidApp that

implements a particularisation of the Pyramid pattern has been used to deploy CSCL activities. The tool provides an activity authoring space and a teacher-facing dashboard for the teachers and an activity enactment space for students. The teacher-facing dashboard not only provided a real-time overview of collaboration but also consisted of different controls, e.g., activity pause-resume, increasing time, and an alerting mechanism that informed critical moments of collaboration to the teachers to support their orchestration actions.

2.3 PyramidApp

PyramidApp is a web-based tool that facilitates the implementation of the Pyramid pattern-based collaborative learning activities [19, 28]. The tool is composed of three main components namely: a) activity authoring/design space; b) activity enactment space and c) activity regulation space. As shown in Fig. 1 first in the activity design stage teachers are required to configure several design elements related to the group activity such as the number of students in class, duration of the script phases, and group size. Once designed the activity can be published to generate an automatic URL that can later be shared with students for enactment. Students can use their mobile phones, tables or laptops to join the activity. The tool also provides a teacher-facing dashboard through which the teacher can monitor collaboration and intervene as required.

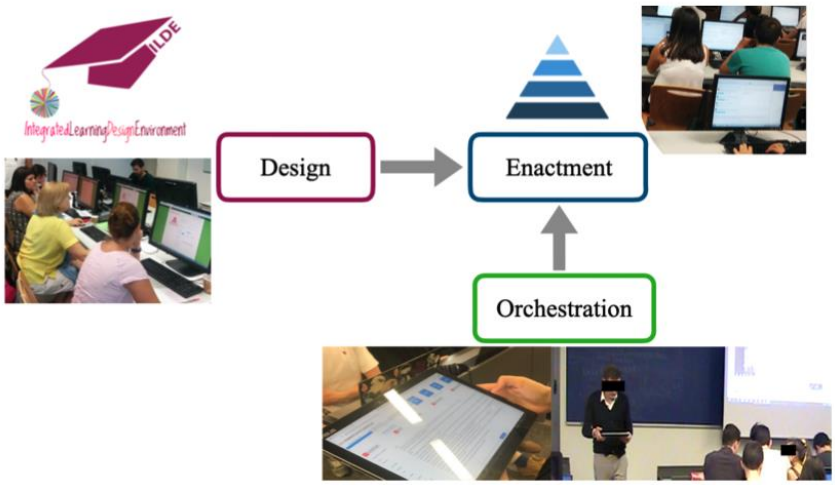

Fig. 1. Different components of PyramidApp

Within the PyramidApp collaboration is structured following a Pyramid structure. After login into the tool, students are required to enter an individual answer to the given problem. At the end of the individual answer submission stage students are randomly allocated into groups where they get an opportunity to see the answers submitted by the fellow group members. At the group levels, students are expected to evaluate the answers from peers. At the end of the voting phase students moved into an option improving phase (see Fig. 2). In this phase students had access to the integrated chat to

engage in discussion with peers and a collaborative text editor (see top-left in Fig. 2) that provided a space for students to write an improved option or to reformulate existing options collaboratively. Students were also shown the average ratings received for each option at the previous rating level (see bottom-left in Fig. 2). At the end of the option improving stage students were promoted to agree on the newly formulated option or to promote the previous answers to further evaluate in the next larger group levels (Fig. 3). Also, all the groups are merged to formulate larger groups. Again, in the larger groups within an individual option evaluation stage students first evaluated the selected options from the previous small group levels individually, then engaged in the option improving stage as discussed earlier. At the end of the activity the selected answers are presented to the students.

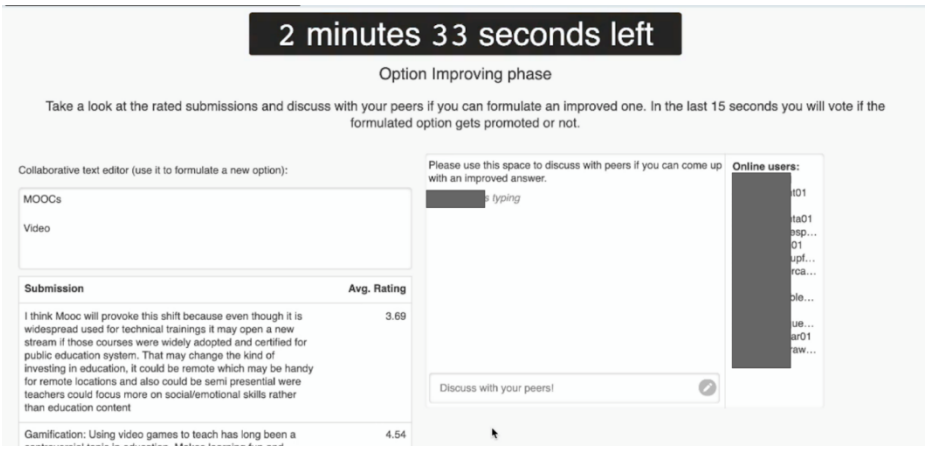

Fig. 2. User interface of the PyramidApp, answer improving space (left), discussion space (right)

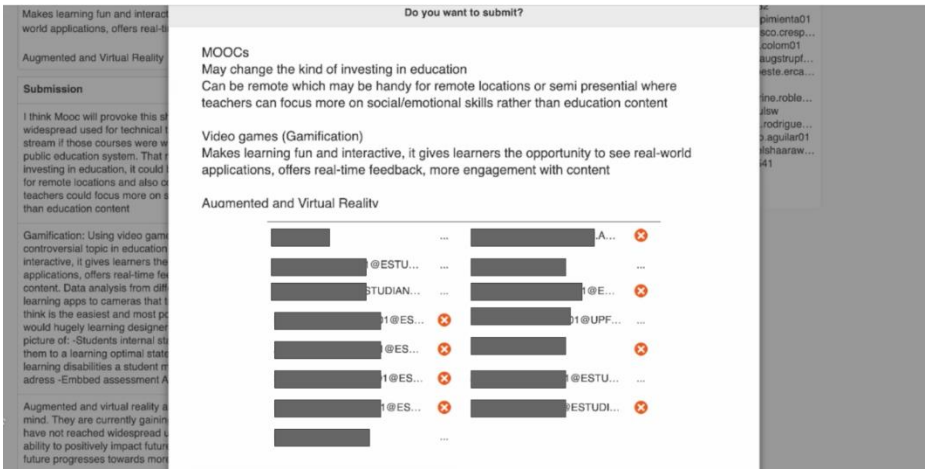

Fig. 3 Agreeing on newly formulated options

3 Methods

3.1 Previous work

The inquiry in this paper belongs to a broader framework where an evaluation process guided by the IEEE P7010-2020 Well-being Impact Assessment (WIA) is applied to evaluate the well-being impact of PyramidApp on its users and stakeholders. As a methodology, WIA consists of five activities: 1) Internal, user, and stakeholder analysis, 2) well-being indicators dashboard creation, 3) data collection plan and data collection, 4) well-being data analysis and use of well-being indicators data, and 5) Iteration [29]. This paper is related to the third activity, aiming at collecting data that can be used to enhance the studied tool's digital well-being. Two of the tool's developers and a sample of the tool's users and stakeholders had participated in surveys and interviews to reflect on a wide range of well-being indicators distributed to multiple well-being domains. The findings discussed possible impacts on the well-being of students and teachers in the areas of life satisfaction, affect (stress), psychological state (sense of capability), community (sense of belonging), education (learning), human settlement (ICT skills), and work (support from peers) [30].

3.2 METUX TENS-INTERFACE

METUX (Motivation, Engagement, & Thriving in User Experience) is a model for bridging Self Determination Theory (SDT) to technology design practice [13]. METUX can be used to evaluate technologies with respect to well-being impact when well-being in this context refers to the "optimal psychological functioning and experience" [31]. The METUX model centres on the well-researched claim [1] that human psychological well-being is mediated by three key constructs: Autonomy (feeling agency, acting in accordance with one's goals and values), Competence (feeling able and effective); and Relatedness (feeling connected to others, a sense of belonging) [13].

METUX proposes that in order to address well-being, psychological needs must be considered within five different spheres of analysis including: at the point of technology *adoption*, during interaction with the *interface*, as a result of engagement with technology-specific *tasks*, as part of the technology-supported *behavior*, and as part of an individual's *life* overall [13]. The data we collect and analyze in this paper is limited to the interface sphere by applying the TENS-Interface questionnaire to a sample of a CSCL tool's student users. When students interact with a learning tool, the satisfaction of the basic psychological needs, via the user interface, predict usability, engagement with technology, and user satisfaction. On the other hand, poor interface usability will cause need-frustration which impacts both engagement and user well-being [13].

3.3 Procedures

A sample of the studied tool's users, 53 first year bachelor students who were enrolled to the same course at a Spanish university, was selected based on convenience sampling. The participants were asked to rate their level of agreement to 15 items using

a 5-point Likert scale (1= Do Not Agree, 5=Strongly Agree). Each key construct (e.g., competence) was measured through five items. All items are weighted equally in scoring, and reverse-scored items are reverse scored. The participants filled the questionnaire after they finished a task facilitated by the tool. All the participants had used the tool to complete collaborative learning tasks at least on three occasions by the time of filling the survey.

4 Findings

4.1 Validity statistics

The measures introduced in METUX were externally validated by the model's developers [13], who carried out a pilot validation study in which 400 participants (100 for each of four technologies) were asked to fill out each METUX questionnaire in reference to one of four possible technologies: Facebook, Google Docs, a music streaming service and a fitness band. Results showed satisfactory to good internal consistency for all questionnaires with alphas for subscales ranging from 0.66 to 0.88. Furthermore, some initial support for the METUX model in higher education was provided by [32], who urged the need for additional validation work to improve the scale that measures need-satisfaction in the interface and task spheres of experience.

We conducted a validity analysis on the TENS-Interface questionnaire comprising five items for each subscale to test their validity in a CSCL context. Cronbach's alpha showed that the competence and relatedness subscales reached good internal consistency levels, $\alpha = 0.85$ and $\alpha = 0.80$ respectively. The autonomy subscale failed to reach the minimum accepted value of Cronbach's alpha, which was found at $\alpha = 0.67$ [13] and had a questionable internal consistency of $\alpha = 0.63$.

Inter-item correlations and item-total correlations were calculated for the autonomy subscale to identify problematic items. Most items appeared to be problematic in this subscale, resulting in low inter-correlations and slight decrease in the Cronbach's alpha if the item was deleted. The one exception to this was the third item (i.e., I feel pressured by the tool), which would significantly decrease the Cronbach's alpha if it was deleted and had a higher item-total correlation and more consistently higher inter-item correlations (Tables 1 and 2).

This outcome aligns with the results from the initial analysis conducted by the tool's creators to evaluate its overall well-being impact [30]. The tool had been found impactful on psychological well-being in the sense of capability, social well-being in the sense of belonging, and affective well-being in the sense of stress. The indicator of autonomy had not been found relevant in earlier stages of this evaluation process [30].

4.2 Scale statistics

The responses of each participant to each 5-item scale were combined by calculating the average score of each participant, then the average score of each scale. The analysis of the participants' responses to the TENS-Interface questionnaire showed that competence was the most satisfied need in the interface of the studied tool (Mean = 3.63), followed by autonomy (Mean = 3.15) and relatedness (Mean= 2.96) (Table 3).

Table 1: Inter-item correlations of autonomy subscale

	The tool provides me with useful options and choices.	I can get the tool to do the things I want it to.	I feel pressured by the tool.	The tool feels intrusive.	The tool feels controlling.
The tool provides me with useful options and choices.	1	0.63	0.30	-0.007	0.008
I can get the tool to do the things I want it to.	0.63	1	0.21	0.04	-0.03
I feel pressured by the tool.	0.30	0.21	1	0.50	0.50
The tool feels intrusive.	-0.007	0.04	0.50	1	0.38
The tool feels controlling.	0.008	-0.03	0.50	0.38	1

Table 2 Item-total correlations of autonomy subscale

Item	Item-total correlation	Cronbach alpha if item deleted
The tool provides me with useful options and choices.	0.59	0.61
I can get the tool to do the things I want it to.	0.55	0.62
I feel pressured by the tool.	0.81	0.44
The tool feels intrusive.	0.60	0.59
The tool feels controlling.	0.61	0.61

Table 3 Descriptive statistics of each subscale

Scale	No. of items	α	n	Mean	Std
Competence	5	0.85	53	3.63	0.79
Autonomy	5	0.63	53	3.15	0.64
Relatedness	5	0.80	53	2.96	0.73

4.3 Visualization

In order to have a global overview of the data, we visualised it in a compact representation through different colours in a percentile system, making it easier to visually digest and compare (Figures 4, 5 and 6).

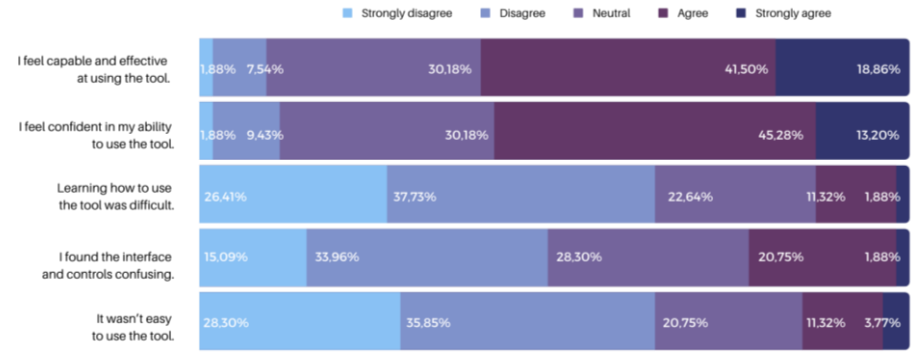

Fig 4. Competence

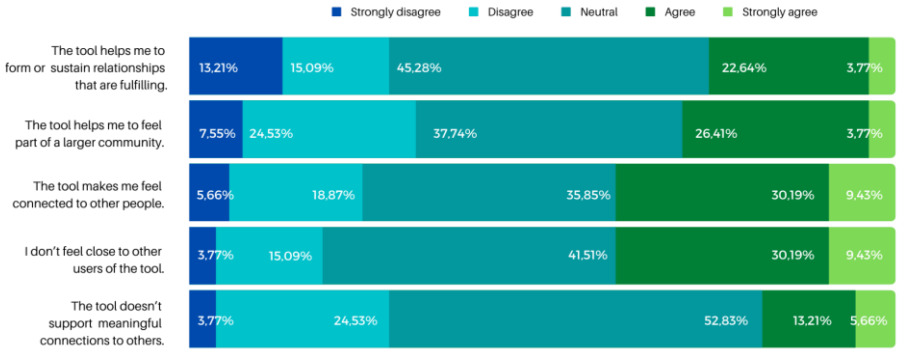

Fig 5. Relatedness

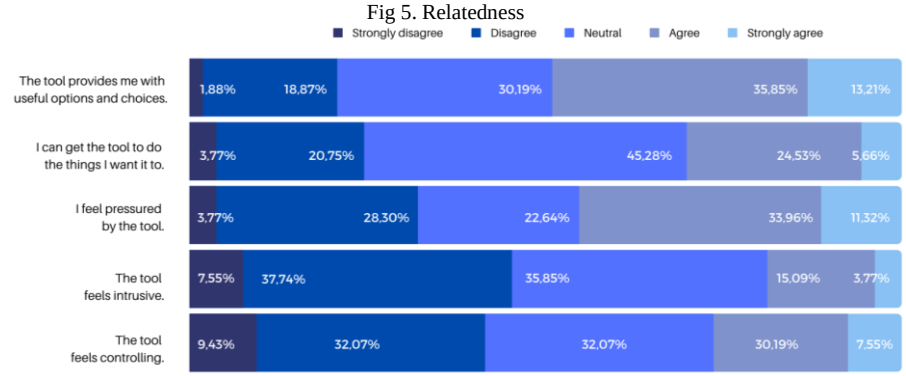

Fig 6. Autonomy

5 Discussion and future work

SDT research and applications have grown significantly over the past two decades, with diverse interests in the relationship between the theory and practice in educational contexts. In this paper, we explore how students' basic psychological needs for autonomy, competence, and relatedness are supported by the interface of a CSCL tool. The responses of 53 students who used the tool to complete collaborative learning tasks reveal that the value of autonomy is not as well defined as competence and relatedness in the interface of the studied tool. The internal consistency of the autonomy scale was questionable ($\alpha = 0.63$), indicating that the user may not clearly perceive this construct while dealing with the tool's interface. Some aspects of the relatedness construct (i.e., sustainable relationships and meaningful connections to others) are not well perceived as about half of the participants hold a neutral position towards them being supported in the tool's interface (Figure 2). In addition, a third of the participants are neutral towards all of the competence aspects, indicating the need for design interventions to improve the interface's ease of use.

As for the TENS-Interface instrument itself, the low level of consistency in results we obtained in the Autonomy component might be due to the way the 5 questions are posed, since the questions can be perceived as generic, especially when the tool has a number of functionalities that we think should be evaluated separately for fuller insight on the true impact the interface has on the autonomy need. Thus, as part of our future work we propose to adapt the questions to each interface element or functionality, rather than compacting them all under the interface as a whole. As a step in this direction (specific to our tool), we propose to iterate the autonomy component of the TENS-Interface instrument, adapting it to the specific elements of the interface before proposing any tool design decisions in regard to autonomy need satisfaction.

On the other hand, related to the two remaining basic psychological needs, and based on the obtained results, since we find that competence was the most satisfied need in the interface of the studied tool (Mean = 3.63), we shift our focus to relatedness (Mean=2.96), which was the least satisfied need. The design implications regarding the relatedness need are to be focused on tool components that facilitate students' interaction and feelings of being connected (i.e., chat, co-editing space and other collaborative components of the interface). The design improvements are to be evaluated by the same TENS-Interface questionnaire.

Overall, we presume that the TENS-Interface instrument requires further improvements before it can be utilized and applied to specific CSCL scenarios. We propose a first improvement in that regard: define the different functionalities of the interface first, then adapt the questions of the three components (autonomy, competence, relatedness) to each one of these functionalities, instead of relying solely on the interface as a whole. This will undoubtedly result in a longer questionnaire, but the results will be just as specific and detailed. Another positive aspect is that there will be more clarity on which components of the interface truly fulfil the three needs and which ones do not.

Acknowledgments. This work has been partially supported by grant PID2020-112584RBC33 funded by MICIN/AEI/10.13039/501100011033. D. Hernández-Leo (Serra Húnter) acknowledges the support by ICREA under the ICREA Academia program. P. Santos acknowledges the support by the Spanish Ministry of Science and Innovation under the Ramon y Cajal programme. E. Hakami acknowledges the grant by Jazan University, Saudi Arabia.

References

1. Ryan, R. M., Deci, E. L.: Self-Determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness. New York, NY: Guilford Press. (2017).
2. Deci, E. L., Ryan, R. M.: Intrinsic motivation and self-determination in human behavior. Plenum Press. [Taylor & Francis Online], (1985).
3. Ryan, R. M.: Psychological needs and the facilitation of integrative processes. Journal of Personality, 63, 397-427. (1995).
4. Ryan, R. M., Deci, E. L: Intrinsic and extrinsic motivations: Classic definitions and new directions Contemporary Educational Psychology, 25 , pp. 54-67. (2000)
5. Ryan, R. M., Deci, E. L.: Self-determination theory and the role of basic psychological needs in personality and the organization of behavior. In O. P. John, R. W. Robins, & L. A. Pervin (Eds.), Handbook of personality: Theory and research (3rd ed., pp. 654-678). New York: Guilford. (2008).
6. Church, A.T., Katigbak, M.S., Locke, K.D., Zhang, H., Shen, J., de Jesús Vargas-Flores, J., Ibáñez-Reyes, J., Tanaka-Matsumi, J., Curtis, G.J., Cabrera, H.F., Mastor, K.A.: Need satisfaction and well-being: Testing self-determination theory in eight cultures. *Journal of Cross-Cultural Psychology*, *44*(4), pp.507-534. (2013).
7. Hsu, H. C. K., Wang, C. V., Levesque-Bristol, C.: Reexamining the impact of self-determination theory on learning outcomes in the online learning environment. Education and Information Technologies, 24(3), 2159–2174. (2019). https://doi.org/10.1007/s10639-019-09863-w
8. Lietaert, S., Roorda, D., Laevers, F., Verschueren, K., De Fraine, B.: The gender gap in student engagement: The role of teachers' autonomy support, structure, and involvement. British Journal of Educational Psychology, 85(4), 498–518. (2015). https://doi.org/10.1111/bjep.12095
9. Roorda, D. L., Koomen, H. M., Spilt, J. L., Oort, F. J.: The influence of affective teacher–student relationships on students' school engagement and achievement: A meta-analytic approach. Review of Educational Research, 81(4), 493–529. (2011). https://doi.org/10.3102/0034654311421793
10. Thomas K. F.: ChiuApplying the self-determination theory (SDT) to explain student engagement in online learning during the COVID-19 pandemic, Journal of Research on Technology in Education, 54:sup1, S14-S30. (2022). DOI: 10.1080/15391523.2021.1891998
11. Ryan, R. M., Deci, E. L.: Intrinsic and extrinsic motivation from a self-determination theory perspective. Definitions, theory, practices, and future directions. Contemporary Educational Psychology, 61, 101860. (2020). https://doi.org/10.1016/j.cedpsych.2020.101860
12. Ryan, R. M., Rigby, C. S.: Motivational foundations of game-based learning. In J. L. Plass, R. E. Mayer, & B. D. Homer (Eds.). Handbook of game-based learning (pp. 153– 176). Cambridge, MA: The MIT Press. (2019).
13. Peters, D., Calvo, R. A., Ryan, R. M.: Designing for motivation, engagement and wellbeing in digital experience. Front Psychol 9: 797. (2018).

14. Sørebø, Ø., Halvari, H., Gulli, V.F., Kristiansen, R.: The role of self-determination theory in explaining teachers' motivation to continue to use e-learning technology. Computers & Education, 53 (2009).
15. Law, W., King, R., Notari, M., Cheng, E., Chu, S.: Why Do Some Students Become More Engaged in Collaborative Wiki Writing? The Role of Sense of Relatedness. In Proceedings of The International Symposium on Open Collaboration (OpenSym '14). ACM, New York, NY, USA, 1–6. (2014). https://doi.org/10.1145/2641580.2641603
16. Calvo, R., Peters, D.: Positive computing: technology for wellbeing and human potential. MIT Press. (2014).
17. Yang, X., Aurisicchio, M.: Designing Conversational Agents: A Self-Determination Theory Approach. In CHI Conference on Human Factors in Computing Systems (CHI '21), May 08–13, 2021, Yokohama, Japan. ACM, New York, NY, USA, 16 pages. (2021). https://doi.org/10.1145/3411764.3445445
18. Hernández-Leo, D., Villasclaras-Fernandez, E. D., Asensio-Perez, J. I., Dimitriadis, Y. A., Symeon, R.: CSCL scripting patterns: Hierarchical relationships and applicability. In: Proceedings of the 6th IEEE International Conference on Advanced Learning Technologies (ICALT 2006), pp. 388–392. (2006). https://doi.org/10.1109/ICALT.2006.1652452
19. Manathunga, K., Hernández-Leo, D. PyramidApp: Scalable Method Enabling Collaboration in the Classroom. In: Verbert, K., Sharples, M., Klobučar, T. (eds) Adaptive and Adaptable Learning. EC-TEL 2016. LNCS, vol 9891. Springer, Cham. (2016). https://doi.org/10.1007/978-3-319-45153-4_37
20. Van den Broeck, A., Ferris, D. L., Chang, C. H., Rosen, C. C.: A review of self-determination theory's basic psychological needs at work. Journal of Management, 42(5), 1195-1229. (2016).
21. Grolnick, W. S., Ryan, R. M.: Parent styles associated with children's self-regulation and competence in school. Journal of Education & Psychology, 81, 43–54. (1989).
22. Deci, E. L., Vallerand, R. J., Pelletier, L. G., Ryan, R. M. Motivation and education: The self-determination perspective. Educational Psychologist, 26, 325–346. (1991).
23. Connell, J. P., Wellborn, J. G.: Competence, autonomy, and relatedness: A motivational analysis of self-system processes. In M. R. Gunnar & L. A. Sroufe (Eds.), Self processes and development. The Minnesota symposia on child psychology Vol. 23 (pp. 43–77). Hillsdale, NJ: Lawrence Erlbaum. (1991).
24. Stahl, G., Koschmann, T. D., Suthers, D. D.: Computer supported collaborative learning: a historical perspective. Cambridge hand-book of the learning sciences, 409– 426. (2006).
25. Hernández-Leo, D., Asensio-Pérez, J. I., Dimitriadis, Y., Villasclaras Fernández, E. D.: Generating CSCL scripts: from a conceptual model of pattern languages to the design of real scripts. Technology-enhanced learning: design patterns and pattern languages, 49-64. (2010).
26. Hernández-Leo, D., Asensio-Pérez, J. I., Dimitriadis, Y.: Computational Representation of Collaborative Learning Flow Patterns Using IMS Learning Design. Educational Technology & Society 8 (4), 75-89. (2005).
27. Hernández-Leo, D., Asensio-Pérez, J.I., Dimitriadis, Y., Villasclaras, E.D.: Generating CSCL Scripts: From a Conceptual Model of Pattern Languages to the Design of Real Scripts. In: Goodyear P.; Retalis, S. (eds.). Technology-Enhanced Learning, Design patterns and pattern languages, Sense Publishers, Series Technology-Enhanced Learning, 49-64. (2010).
28. Manathunga, K., Hernández-Leo, D.: Authoring and enactment of mobile pyramid-based collaborative learning activities. British Journal of Educational Technology, 49(2), 262–275 (2018). https://doi.org/10.1111/bjet.12588
29. IEEE: IEEE Recommended Practice for Assessing the Impact of Autonomous and Intelligent Systems on Human Well-Being. IEEE Std 7010-2020, pp.1–96 (2020). https://doi.org/10.1109/IEEESTD.2020.9084219

30. Hakami, E., Hernández-Leo, D., Amarasinghe, I.: Understanding the Well-Being Impact of a Computer-Supported Collaborative Learning Tool: The Case of PyramidApp. In: De Laet, T., Klemke, R., Alario-Hoyos, C., Hilliger, I., Ortega-Arranz, A. (eds) Technology-Enhanced Learning for a Free, Safe, and Sustainable World. EC-TEL 2021. LNCS, vol 12884. Springer, Cham. (2021). https://doi.org/10.1007/978-3-030-86436-1_38
31. Ryan, R. M., Deci, E. L.: On Happiness and Human Potentials: A Review of Research on Hedonic and Eudaimonic Well-Being. Annual Review of Psychology, 52(1), 141–166. (2001).
32. Jeno, L. M., Diseth, Å., Grytnes, J. A.: Testing the METUX model in higher education: interface and task need–satisfaction predi]ct engagement, learning, and well-being. Frontiers in Psychology, 105. (2021).