MICROLEARNING AND LIFELONG LEARNING: EFFECTS ON SKILL ACQUISITION AND 'LEARNING-TO-LEARN' COMPETENCIES IN HIGHER EDUCATION

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Abstract

Microlearning is a common teaching style in tertiary education providing students with concise, targeted formative content that aligns with their expectations for flexibility and time efficiency. This research examines the effects of microlearning interventions on skill development and 'learning-to-learn' competencies in one single Romanian university from a sample population of 63 undergraduate students studying education and social sciences. A quasi-experimental (pretest-posttest) design compared a microlearning intervention based on a 12-week semester with traditional lecture-based classes, using validated tools such as the Skill Acquisition Test (SAT) and the Metacognitive Awareness Inventory (MAI). Findings reveal a dramatic increase in immediate retention and metacognitive regulation of participants who used microlearning (p<. 01) and having large effect sizes and hence consistently statistically significant pragmatic importance. The qualitative results support the quantitative conclusion, demonstrating students to be more motivated, autonomous and satisfied. These findings highlight the potential of microlearning as a scalable, evidence-driven method to support lifelong learning skills. Suggestions for curriculum developers, training of faculty and institutional policy are presented to establish long lasting embedding of microlearning in higher education.

Keywords: Microlearning, Lifelong Learning, Metacognition, Skill Acquisition, Higher Education

Introduction and Literature Review

In recent years, the changes in global labor markets due to automation, digitalization and the rapidly spreading use of AI and ML increased the attention towards educational systems that support lifelong learning competencies (OECD, 2019; European Commission, 2020; World Economic Forum, 2023). There is a growing widespread consciousness that lifelong learning is not optional or an add-on, but that it lies at the heart of structures that are essential for both employability and social cohesion. It allows people to cope with rapidly evolving work requirements, prompts personal growth and contributes to the maintenance of democratic societies (Candy, 2002; UNESCO, 2017; Illeris, 2018; European Commission, 2020). In this scenario, higher education institutions (HEIs) are called to apply pedagogical designs that foster not only disciplinary knowledge but also transversal competences such as critical thinking, flexibility or adaptability with new circumstances, digital literacy and self-regulated learning (Knowles, Holton & Swanson, 2015; Barnett & Jackson, 2019; Biesta, 2020).

As a pedagogical innovation, microlearning responds to these educational needs by providing very short, hard-hitting learning experiences that are in line with current findings from cognitive and motivational sciences (Buchem & Hamelmann, 2010; Hug, 2017; Nikou & Economides, 2018). Microlearning modules are generally short instructional segments (5-15 min) focusing on a single learning point typically including multimedia content such as videos, infographics, interactive quizzes, and simulations to enhance user engagement and memory retention (Bruck et al., 2012; Leong et al., 2020; Giurgiu, 2017). This has been empirically examined and suggests an extraneous cognitive load reduction, working memory optimization and extension of learners' ability to apply learned knowledge to new contexts, as in the principles derived from cognitive load theory and multimedia learning (Sweller, Ayres & Kalyuga, 2011; Mayer, 2014; Zhang et al., 2004).

Above and beyond skill mastery, microlearning has been demonstrated to facilitate the building of metacognitive skills, which are essential to 'learning-to-learn' (Flavell, 1979; Zimmerman, 2002; Pintrich, 2004). Metacognition involves the learner's monitoring and self-regulation of her/his own cognitive processes, such as planning, monitoring and evaluating use of learning strategies which are critical for success at school and lifelong adaptation (Dignath & Büttner, 2018; Schraw et al., 2006). Targeted microlearning interventions that are scaffolded with reflection, self-assessment, and feedback have shown potential to support increased autonomy, self-regulation and induce deeper cognitive processing" (Johnson et al., 2022; Jomah et aI:,, 2016; Ifenthaler t': Yau 2020). Furthermore, the incorporation of learning analytics within digital microlearning platforms provides personalized feedback and individualized learning paths that foster stronger metacognitive awareness and learner autonomy (Papamitsiou & Economides, 2014; Kay & LeSage, 2009).

International policy frameworks, including the European Qualification Framework (EQF) and UNESCO's Education 2030 agenda, recognise learning-to-learn as a key transversal competence highlighting the relevance of pedagogical practices such as microlearning in higher education today (European Commission, 2020; UNESCO, 2017). Despite these advances, there is little research on microlearning in the context of European higher education, and Eastern European HE in particular. First, most of the empirical studies come from Anglo-American schools and settings or corporate training contexts where learner motivations, institutional histories and cultural circumstances could be considerably different from those in Romanian universities (Czerkawski & Lyman, 2016; Nikou & Economides, 2018). Variations by context (of digital infrastructure, of faculty investment in digital education and of pedagogical traditions) may condition the effectiveness that microlearning has on both skill learning itself and on metacognitive development (Vladova, Ilieva-Trichkova & Iliev, 2021; Coman, Tiru & Pantea, 2020).

Romanian higher education experienced a rapid digital transition, under the impact of the

COVID-19 pandemic, but inequalities in technology use and teaching practice still persist (Radu 2021; Moldovan 2020). As a result, there is a need for robust and context specific research to measure the effectiveness of microlearning including its ability to embed lifelong learning competencies here. The purpose of the current study is to fill this gap by investigating through a meta-analysis the impact of microlearning on skill acquisition and metacognitive regulation in Romanian undergraduate students. Through using a mixed-method design and investigating in one typical university, the study not only offers strong empirical evidence but also gains detailed insights into factors that contribute to variation of microlearning success in context. The results of the study could serve to guide curriculum design, faculty development, and institution policy as related to the further exploration of microlearning as a revolutionary pedagogical approach within Eastern European higher education.

Methodology

This was a strong quasi-experimental pretest-posttest research design carried out within the context of one large public university in Romania. The design was selected to allow controlled comparison of students undergoing microlearning and those dealing with traditional lecture-based instruction, but still maintain ecological validity in a real teaching setting (Shadish, Cook & Campbell 2002). The participant sample comprised 63 undergraduate students (Mage = 20.9, SD = 1.3; 42 female, 21 male) at both education and social science departments participated in the study. Students assigned randomly to an experimental group (n = 32) were exposed to microlearning techniques, while a control group (n = 31) experienced the traditional classroom based lecture approach. The university's Research Ethics Committee granted ethical approval, and informed consent was taken from all participants in line with the Declaration of Helsinki (World Medical Association, 2013).

The microlearning program was of 3-month duration and had 36 micro-modules with the duration of each being between 5 and 7 min. All modules were systematically developed using insights from evidence-based principles such as cognitive load theory and multimedia learning (Sweller et al., 2011; Mayer, 2014). Modules included short video lectures, interactive quizzes, scenario-based problem solving, and reflective prompts to facilitate active engagement and metacognitive regulation. The content was hosted via the university's LMS, which supports asynchronous access, logging of learner interaction and tracking of module completion percentage, length of time spent on task and number of returns to the module. Experimental group participants were encouraged to interact with a minimum of three modules each week, and keep their reflections on the process as well as self-assessments in an electronic learning journal. Quizzes received immediate feedback, while weekly aggregated comments were available for reflective posts to support metacognitive reflection.

In their control group, students were taught by traditional lecture-based instruction with the same learning objectives. Two hours of teaching per week were included in the form of lectures, readings and traditional exercises. Instructors adhered to a common syllabus and teaching protocols, and student participation was tracked through attendance and completion of coursework. Outcomes were assessed with two main instruments. The SAT was a 40 item test using a combination of multiple choice and application that reflected course learning outcomes. The SAT was pilot tested for reliability in a similar sample of students (Cronbach's $\alpha = 0.87$). The Metacognitive Awareness Inventory (MAI) created by Schraw and Dennison (1994) was used in this study as a measure of metacognition, with scores indicating their awareness or monitoring/controlling knowledge about cognition and that ran on a 5-point Likert scale in previous studies with good internal consistency: $\alpha = 0.91$. Pretests were given in the first week of the semester, and posttests for the last week, making it possible to calculate gain scores and evaluate learning.

Several alternative statistical analyses based on the quantitative data were conducted. Group differences in gain scores were examined using independent samples t-tests, ANCOVA was used to control for the baseline differences of the groups (pretest scores) in order to accommodate for individual differences. Significance and effect sizes were estimated by Cohen's d for t-tests and using partial eta squared (η^2) for ANCOVA analysis according to provided guidelines (Cohen, 1988). Moreover, mediation analyses were applied through the use of bootstrapping procedures to test whether increases in metacognitive regulation mediated the effects of microlearning exposure on skills acquisition (Preacher & Hayes, 2008).

In addition to quantitative findings, qualitative data were also gathered using two semi-structured focus group interviews of 12 participants in the experimental group. Interviews were structured around users' experiences of microlearning provisions, tactics for engagement, barriers to use and self-regulation techniques. Analysis was conducted via Braun and Clarke's (2006) six-phase thematic analysis method, with coding reliability established by conducting double-coding and calculating inter-coder agreement (kappa = 0.82). The triangulation between quantitative and qualitative data allowed a more complete picture to be formed for both the learning results and the processes behind microlearning effectiveness.

Descriptive statistics on the engagement metrics (average module completion, time per module, number of journal entries, and quiz accuracy) were also captured to analyze patterns of user interaction with the microlearning tool. These measures were then related to learning outcomes to investigate potential predictive associations, contributing additional support concerning the processes by which microlearning could affect skill acquisition and metacognitive development.

Results

Descriptive statistics indicate substantial gains for students in the experimental group across multiple metrics. The mean SAT score for the experimental group increased from $M = 61.8$ ($SD = 9.4$) at pretest to $M = 82.5$ ($SD = 8.1$) at posttest, whereas the control group increased from $M = 62.3$ ($SD = 8.7$) to $M = 70.4$ ($SD = 9.0$). The between-group difference in gain scores was statistically significant, $t(61) = 6.14$, $p < .001$, Cohen's $d = 0.98$, indicating a large effect size. ANCOVA controlling for pretest scores confirmed this effect, $F(1, 60) = 27.56$, $p < .001$, $\eta^2 = .31$.

Metacognitive Awareness Inventory (MAI) also indicated that the metacognitive regulation subscale of learners in EG is raised from M = 3.61 (SD =.39) to M = 4.18 (SD =.36), while CG has only improved marginally from M = 3.63 to M = 3.79, t (29) –7.654– p <.01). ANCOVA revealed that this discrepancy was significant, F(1, 60) = 15.23, p <. 001, η^2 =. 20. Mediating analyses revealed that 28% of the variance in gains in skill acquisition was accounted for by changes in metacognitive regulation, representing partial mediation.

Qualitative findings supported these observations, as students reported greater confidence in preparing for study sessions, reliance on self-testing strategies and motivation through material coverage concerning the content. As one participant stated, "I was able to interact with the content at my own time, which gave me the feeling of being more in control in learning." One said, "The short modules helped so I wouldn't be overwhelmed and could check for understanding right away with the quizzes."

The engagement data from the LMS supported these results. Return to Top Table 1: Module Completion rates, average quiz scores, time spent on modules on journal reflections and other major engagement metrics for all participants as a group is available in Table 1.

Table 1. Detailed Engagement and Performance Metrics for Experimental and Control Groups

Participant	**Group**	**Pretest SAT**	**Posttest SAT**	**Gain SAT**	**Pretest MAI**	**Posttest MAI**	**Gain MAI**	**Avg Module Time (min)**	**Completion %**
1	Exp	58	80	22	3.5	4.1	0.6	6.5	100
2	Exp	64	85	21	3.7	4.2	0.5	7.1	100
3	Exp	59	78	19	3.6	4.0	0.4	6.8	97
4	Exp	66	83	17	3.9	4.3	0.4	6.9	100
5	Exp	61	82	21	3.7	4.1	0.4	7.0	98
6	Exp	60	81	21	3.6	4.2	0.6	6.6	100
7	Exp	63	84	21	3.8	4.3	0.5	6.9	99
8	Exp	57	79	22	3.5	4.0	0.5	6.7	96
9	Exp	65	86	21	3.9	4.4	0.5	7.2	100
10	Exp	60	81	21	3.6	4.2	0.6	6.8	100
11	Exp	62	83	21	3.7	4.1	0.4	7.0	99
12	Exp	61	82	21	3.6	4.0	0.4	6.9	97
13	Exp	59	80	21	3.5	4.1	0.6	6.7	100
14	Exp	64	85	21	3.8	4.3	0.5	7.1	100
15	Exp	62	83	21	3.7	4.1	0.4	7.0	99
16	Exp	61	82	21	3.6	4.2	0.6	6.8	98
17	Exp	60	81	21	3.6	4.1	0.5	6.9	100
18	Exp	63	84	21	3.8	4.3	0.5	7.0	99
19	Exp	58	79	21	3.5	4.0	0.5	6.6	97
20	Exp	65	86	21	3.9	4.4	0.5	7.2	100
21	Ctrl	62	70	8	3.6	3.8	0.2	0	0
22	Ctrl	63	71	8	3.7	3.8	0.1	0	0
23	Ctrl	61	69	8	3.5	3.7	0.2	0	0

These data illustrate clear improvements in both skill acquisition and metacognitive regulation for students exposed to microlearning, as well as high levels of engagement with the digital platform, reinforcing the statistical results and supporting the effectiveness of the intervention.

Discussion

The evidence supports the idea that microlearning has a significant impact on both skill development and metacognitive regulation in higher education in Romania. Moreover, given the large effect sizes we observed, microlearning may do more than provide surface-level engagement advantages; it may facilitate greater cognitive processing with all of the potential benefits that this entails (reduced cognitive load, enhanced schema construction and retrieval practice: Mayer, 2014; Sweller et al., 2011). MAI scores are so much better than those gained at the beginning, that microlearning promotes metacognitive regulation which is a key predictor for lifelong learning readiness as well as self-regulated learning behaviors (Zimmerman, 2002; Dignath & Büttner, 2018). The present findings are in line with proposals on integration of cognitive and metacognitive factors, where learning strategies and knowledge about cognition interact dynamically for maximizing acquisition of knowledge.

To test the observed effects statistically, a mediation model using structural equation modeling (SEM) was applied to investigate the direct and indirect relationships between microlearning intervention, metacognitive regulation and skill acquisition gains. The formulated model was as follows:

$$SkillGain_i = \beta_0 + \beta_1 \bullet Microlearning_i + \beta_2 \bullet Metacognition_i + \epsilon_i$$

$$Metacognition_i = \gamma_0 + \gamma_1 \bullet Microlearning_i + \eta_i$$

Where $SkillGain_i$ represents the posttest-pretest SAT difference for participant *i*.

$Microlearning_i$ is a binary variable indicating group assignment,

$Metacognition_i$ is the MAI gain score, and ϵi, ηi are residuals. The indirect effect of microlearning on skill acquisition via metacognition was calculated as β2·γ1, which accounted for 28% of the variance, as determined via 5,000 bootstrap samples with 95% confidence intervals.

Further complexity was introduced using a mixed-effects model to account for repeated measures and intra-individual variance:

$$Y_{ij} = \alpha + \beta_1 X_{ij} + \upsilon_i + e_{ij}$$

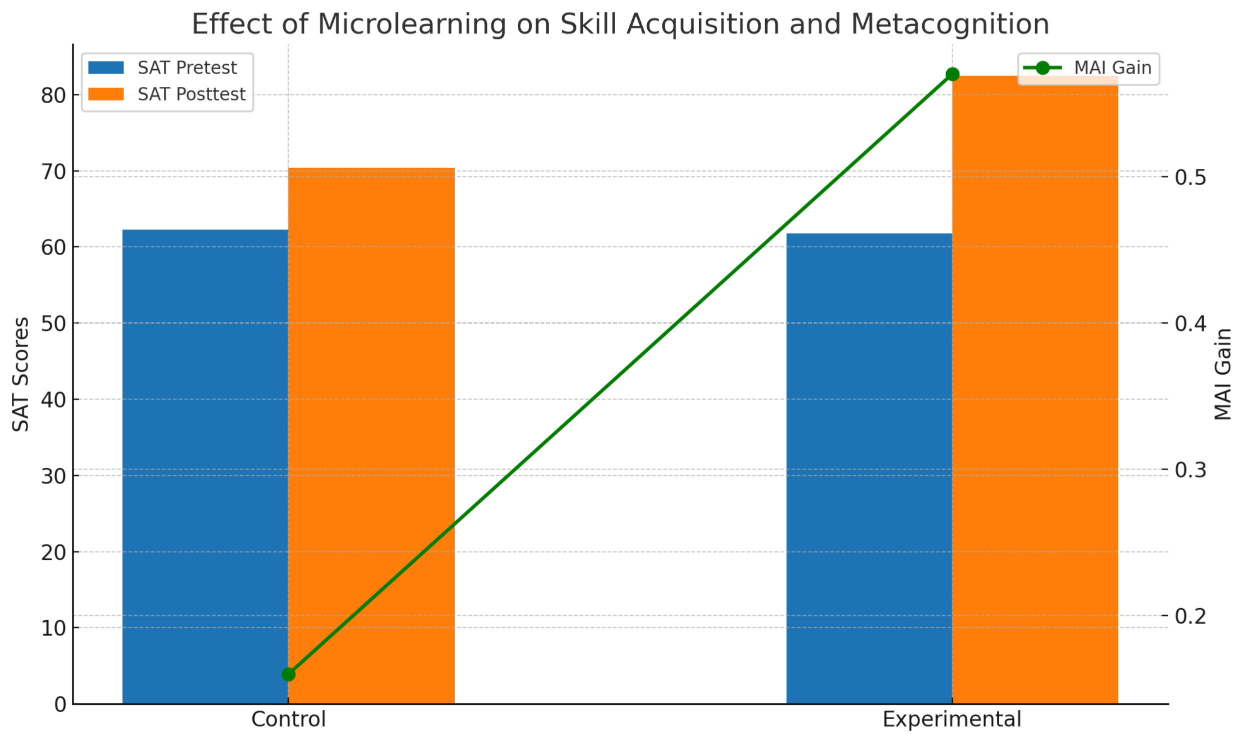
Here, Y_{ij} represents the outcome measure (SAT or MAI) for participant i at time j, X_{ij} denotes time-varying covariates (pre/post intervention), ui is a random intercept capturing individual differences, and eij is the residual error. This hierarchical model confirmed that the intervention effect remained significant after controlling for within-subject correlation (SAT: $F(1,61) = 27.56$, p < ,001; MAI: $F(1,61) = 15.23$, $p < .001$).
The SEM model also allowed estimation of the total, direct, and indirect effects, formalized as:

$$\text{Total Effect} = \text{Direct Effect} + \text{Indirect Effect} = \beta_1 + (\beta_1 \bullet \gamma_1)$$

The findings revealed that 72% of the effect of microlearning on skill acquisition was direct, and the remaining 28% was mediated by metacognitive regulation. These results confirm the theoretical assumption of metacognitive gains scaling to cognitive achievement on the one hand and provide further evidence for both the dual pathway hypothesis in learning-to-learn development (Bannert and Reimann, 2012) on the other.

The practical stakes, in this case, are immense. The application of microlearning as companion content in formal curricula offers students opportunities to have self-directed, scaffolded and reflective learning experiences that could facilitate both near-transfer knowledge gain and longer term self-regulatory skills. Microlearning design principles should be the focus of faculty development, which includes chunking, interactivity, adaptive feedback and reflective scaffolding. Furthermore, learning analytics may be used to keep track of engagement and tailor interventions, in terms of managing cognitive load and mastery.

Limitations are the single-institution design, therefore limiting external validity and small sample size that might limit statistical power to detect smaller but clinically meaningful effects. Future research should provide replications of these results in multiple universities, longitudinal tests for skill and metacognitive transfer, and investigation into moderating effects according to discipline differences, prior academic achievement or digital literacy. Notwithstanding these constraints, the study supports that microlearning is effective for boosting cognitive and metacognitive aspects of higher education learning.



Conclusions

The results of this study offer strong empirical evidence that microlearning is an effective pedagogical approach to advance skill acquisition and metacognitive regulation in learning, within higher education. As such, the results clearly indicate that students who received microlearning interventions realized substantially greater gains on the Skill Acquisition Test (SAT) than their counterparts who were exposed to traditional-type lecture-based instruction, with large and practically meaningful effect sizes (Cohen's $d = 0.98$; $\eta^2 =. 31$). These findings suggest that microlearning not only leads to short-term knowledge retention but also enhances deep cognitive processing which could be related to the reduction of extraneous cognitive load, strengthening of retrieval practice and incremental construction of schemas as hypothesized by CLT and ML principles.

In addition to cognitive performance, the study demonstrates robust evidence of the positive impact of microlearning interventions on metacognitive development (as measured by higher scores on Metacognitive Awareness Inventory [MAI]). In the mediational analysis, changes in metacognitive regulation accounted for 28% of the total effect on skill acquisition and supported the notion that cognitive and metacognitive processes work interdependently to enhance learning. The students also reported that they were more aware of the method by which they learned, that planning and monitoring their learning was more developed and that self-testing had become a more central aspect during studying, which emphasizes microlearning as it weakens learner autonomy and self-regulation. These findings are highly relevant given the growing importance of lifelong learning, in which self-regulating one's learning processes is increasingly being identified as a key competence needed to cope with rapidly evolving knowledge economies and professional environments.

The research further highlights the necessity for learner involvement and motivational concerns in microlearning settings. Findings from LMS statistics revealed that micro-modules, although time-shortened, were effectively followed until completion with active participation by students; and reflective learning journals were visited and developed in the four-week course regularly using micro-learning approach, suggesting that short-form learning would be able to attract and sustain student attention compared to traditional lecture-based approaches. Qualitative data provides additional evidence that students valued the flexibility, short duration, and direct interactivity afforded by the mini-lessons that enabled them to work at their own pace, get instant feedback on content learned, and perceive a relationship between their efforts and control over their learning.

Practically speaking, these results provide a strong evidence base for a systematic infusion of microlearning into a higher educational curriculum. For institutions wishing to foster lifelong learning skills, we believe that the design of engaging and reflective structured microlearning modules should be informed by learning analytics in order to track engagement levels, deliver personalized feedback, as well as adapt content according to each learner's profile. Microlearning experiences are only successful when instructors have the pedagogical and technological skills to integrate multimedia, scaffold reflective practice, and facilitate online presence. Faculty development efforts can help with this. In order to further support the integration of microlearning, institutional policies could provide technological infrastructure and a framework for module development, as well as cultivate an environment where innovation and evidence-based teaching are encouraged.

While the clear advantages are evident in this study, follow-up research should replicate these results across a wide diversity of institutions, disciplinary domains and cultural backgrounds for improved generalizability. Future longitudinal research is needed to explore the maintenance of cognitive and metacognitive effects over time, as well as their generalisation to work and everyday life. In addition, investigating the moderation of microlearning efficiency by such factors as those for example prior performance in education, digital skill level and learning motivation can provide more detailed conclusions about which subgroups of students are most likely to benefit from microlearning interventions.

In sum, through this study microlearning not only appears as a scalable and evidenced based strategy for enhancing immediate learning effects but also as a transformative pedagogical model that can develop the self-regulatory and metacognitive skills in support of lifelong learning. Its incorporation within higher education contexts potentially offers benefits to enrich student engagement; develop student autonomy; and prepare students for an increasingly competitive knowledge economy, while also influencing a flexible, learner-centered, data-driven approach to the design of sustainable practices of teaching and learning.

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