Comparing pre-service and in-service teacher perceptions of the science of learning

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1. ABSTRACT

This paper presents the results of a survey on teacher formation and beliefs related to the science of learning (SOL). Results suggest there is a gap, as perceived by both in-service and pre-service teachers, in teacher knowledge and confidence related to SOL. This gap exists despite most teachers indicating that SOL should be a required part of initial teacher education. Overall, the results suggest that teachers would be receptive to interventions that improve their knowledge of SOL.

2. KEYWORDS: 4-6

Science of Learning, Teacher Training, Teacher Education

3. DESENVOLUPAMENT:

Introduction

The Council of the European Union writes that "initial teacher education should provide prospective teachers with the core competences required to deliver high quality teaching" (E.U. Council, 2014). However, a study by the National Council on Teacher Quality that reviewed teacher training programs in the United States reported that "aspiring teachers are not being taught — in textbooks or in their coursework and training — the foundational knowledge about cognitive strategies that can help ensure children will learn" (Pomerance, Greenberg & Walsh, 2016). This is despite persistent efforts to disseminate "proven practices that promote learning for all students" (Roediger & Pyc, 2012) and teacher interest in interventions based on neuroscience (Simmonds, 2014). Does this gap in knowledge which can undermine competences exist in European contexts? This paper presents 1) the results of **a survey on teacher formation and beliefs related to the science of learning** completed by in-service and pre-service teachers in Barcelona, Spain; and 2) participant **evaluations** of a 2.5-hour workshop that aimed to impact educator knowledge and beliefs related to the science of learning. The science of learning (also referred to as learning sciences) is "interdisciplinary, drawing on multiple theoretical perspectives and research paradigms so as to build understandings of the nature and conditions of learning, cognition, and development" (Barab & Squire, 2004; p. 1). The aim of the science of learning is to better understand and support human learning. The motivation for the study was to collect evidence of teacher needs and preferences in order to inform future teacher professional development (PD) interventions and to gather feedback on the existing workshop intervention as part of a design-based research (DBR) approach (Cole, Purao, Rossi & Sein, 2005).

A Science of Learning Primer for Educators

Short modules have been shown to improve teacher knowledge about the brain and learning (Dekker & Jolles, 2015). Thus, in collaboration with neuroscientists, a 2.5-hour workshop was developed (Beardsley, 2019) to provide educators with an overview of the cognitive processes that underlie student learning and to highlight common teaching practices that are consistent with cognitive principles of learning (see Figure 1). The workshop was created as an open educational resource as part of a European project (http://illuminatedproject.eu/). The learning objectives of the training were to increase teacher understanding of durable and efficient learning; to have teachers reflect on their current practices through a science of learning lens; and, ultimately, to motivate teachers to learn more about the science of learning.

Data Collection/Analysis

The study involved participants completing a pre-survey online prior to the workshop. The pre-survey questions are shown in Table 1 and explore prior formation and beliefs related to the science of learning. Within 24 hours of completing the workshop, participants received a link to a post-survey to complete online. The post-survey questions are shown in Table 2 and relate to the evaluation of the workshop and ask participants to reassess their beliefs related to the science of learning. Both surveys were created as Google Forms.

Four groups of teachers participated in the pre and post survey study. One group was made up of pre-service teachers and the remaining three groups were in-service teachers (Table 3). For the purpose of our study, pre-service teachers were those enrolled in an initial teacher education program. In-service teachers were actively employed school teachers. A total of 22 pre-service teachers completed the pre-survey and 24 the post-survey; 73 in-service teachers completed the pre-survey and 52 the post-survey. As the surveys were completed online, not all participants completed both surveys. Further, the first group of in-service teachers did not have all survey questions in their survey as some questions were added for the later groups. Table 4 shows the responses per question.

Beliefs about the utility of the science of learning

Pre-service teacher (Figure 2A) and in-service teacher (Figure 2B) beliefs about the utility of learning about the science of learning were analyzed using questions 1A, 1B, and 1C of Table 1. The results are as follows:

Usefulness: 86.36% of pre-service teachers and 79.45% of in-service teachers agreed or strongly agreed that learning about the science of learning (e.g. how learning happens) would be useful for educators. *Necessity:* 86.36% of pre-service teachers and 83.56% of in-service teachers agreed or strongly agreed that they feel it is necessary for educators to understand the science of learning in order to understand what educational practices are effective or ineffective. *Requirement:* 86.36% of pre-service teachers and 85.37% of in-service teachers agreed or strongly agreed that learning about the science of learning should be required as part of a teacher's professional formation (e.g. initial teacher education).

Science of learning beliefs

Pre-service teacher (Figure 3A) and in-service teacher (Figure 3B) self-assessments of knowledge related to the science of learning were analyzed using questions 1D, 1E, and 1F of Table 1. The results are as follows:

Sufficient formation: Over half (59.09%) of pre-service teachers and in-service teachers (63.41%) disagreed or strongly disagreed that they have received sufficient formation (e.g. training) related to how students learn. No respondents strongly agreed that they had received sufficient formation. *Confidence:* Over half (54.55%) of pre-service teachers and 47.95% in-service teachers disagreed or strongly disagreed that they had confidence in their knowledge of how students learn. *Teaching practice alignment:* Less than a fifth (18.18%) of pre-service teachers and quarter (24.39%) of in-service teachers agreed or strongly agreed that their teaching practices were consistent with scientific literature related to how people learn.

Evaluation of the workshop

Pre-service teacher (Figure 4A) and in-service teacher (Figure 4B) evaluations of the *Illuminated Science of Learning Primer for Educators* workshop were analyzed using questions 2A, 2B, 2C and 2D of Table 2. The results are as follows:

Workshop usefulness: 91.67% of pre-service teachers and 94.23% of in-service teachers agreed or strongly agreed that the workshop was useful for educators. *Application clarity:* However, only 45.83% of pre-service teachers and 73.08% of in-service teachers agreed or strongly agreed that it was clear how they could apply what they learned in the workshop to their teaching practices. *Necessity:* Post-workshop more teachers agreed or strongly agreed that they feel it is necessary for educators to understand the science of learning in order to understand what educational practices are effective or ineffective (pre-service teachers: from 86.36% to 91.67%; in-service teachers: from 83.56% to 90.32%). *Requirement:* Post-workshop 87.50% (pre-workshop 86.36%) of pre-service teachers and 83.33% (pre-workshop 85.37%) of in-service teachers agreed or strongly agreed that learning about the science of learning should be required as part of a teacher's professional formation (e.g. initial teacher education or continuing professional development).

Post-assessment of science of learning beliefs

Pre-service teacher and in-service teacher post-workshop beliefs related to the science of learning were analyzed using questions 2E and 2F of Table 2. The results are as follows:

Confidence: Post-workshop fewer teachers disagreed or strongly disagreed that they had confidence in their knowledge of how students learn (pre-service teachers: from 54.55% to 16.67%; in-service teachers: from 47.95% to 16.13%). *Teaching practice alignment:* Post-workshop more teachers agreed or strongly agreed that their teaching practices were consistent with scientific literature related to how people learn (pre-service teachers: from 18.18% to 33.33%; in-service teachers: from 24.39% to 32.26%).

Discussion

Part of the motivation for this study was to collect evidence of teacher needs and preferences in order to inform future teacher PD interventions. This motivation aligns with the first stage of the 4-stage DBR model (Cole, Purao, Rossi & Sein, 2005) being followed – the stage of *problem definition*. As Bereiter (2002) writes, the "most immediate goal of design research is the solution of problems formulated on the basis of perceived shortcomings and obstacles." As revealed by the pre-survey results, 54.55% of pre-service teachers and 47.95% of in-service teachers did not have confidence in their knowledge of how students learn. Further, less than a fifth (18.18%) of pre-service teachers and quarter (24.39%) of in-service teachers believed that their teaching practices were consistent with scientific literature related to how people learn. Thus, the survey results suggest that the gap in teacher knowledge of the science of learning exists among Spanish teachers – and additional interventions to help improve teacher knowledge and practices are needed.

The study also aimed to gather feedback on an existing workshop intervention as part of the second and third stages of the 4-stage DBR model being followed. These stages, *intervention* and *evaluation*, intertwine as part of iterative cycles that are central to DBR. Overall, the evaluations of the workshop intervention suggest that the 2.5-hour workshop was found to be useful for teachers and helped reduce their uncertainties related to the science of learning. However, the clarity with which the taught material could be applied to a teacher's practices could be improved.

It is important to get a better understanding of what teachers know, how motivated they are to learn, and what works in terms of improving their knowledge and, ultimately, their practices. Reporting on any of these aspects can benefit both researchers and practitioners looking to develop their own PD interventions. In a review of teacher PD studies, Kennedy (2016) writes:

> We need to replace our current conception of "good" PD as comprising a collection of particular design features with a conception that is based on a more nuanced understanding of what teachers do, what motivates them, and how they learn and grow. (p. 30)

This study contributes to such a nuanced understanding of teacher beliefs and needs – framed within a larger objective of working toward design principles that can help guide effect PD related to the science of learning.

Limitations

This study has been conducted with Spanish in-service and pre-service teachers. It is unclear how generalizable the findings are as teacher education and PD differs greatly across Europe. Moreover, the evaluation of the lesson used qualitative measures rather than a validated instrument for evaluating learning. The study did not track whether the intervention resulted in any changes to teacher practices over time. These limitations should be addressed in future work.

Future Work

Involving more teachers from other European countries, integrating objective measures of teacher knowledge and practices as they relate to the science of learning; and improving or extending the workshop to make it clearer to participants how they can directly apply what they learn in the workshop to their teaching practices are anticipated to be near future work. Further, the intervention workshop was created as an introductory session to the science of learning. It is envisaged that additional sessions would follow in which teachers revise lesson plans to integrate teaching strategies that align with durable and efficient learning – as identified by the science of learning. This more complete training would be integrated into the study plans and continuous training of teachers. At such time, the iterative intervention and evaluation cycles of DBR would be able to provide enough evidence to move on to the final stage of the DBR model, *reflection and learning*. This would facilitate the generation of design principles that could be used to guide future PD interventions related to the science of learning.

Conclusion

The study results suggest that there may be a gap, as perceived by the educators themselves, in teacher knowledge and confidence related to the science of learning. This gap was found both among pre-service and in-service teachers despite the vast majority of educators indicating that the science of learning should be a required part of initial teacher education. Moreover, the short workshop was perceived by all groups of teachers to be useful and improved their self-ratings related to confidence in knowledge about learning and alignment of their teaching practices. These results suggest that educators are uncertain in their knowledge about the science of learning but a 2.5-hour workshop can help reduce these uncertainties.

Acknowledgements

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3.1. TABLE 1

Table 1. Pre-survey questions

ID	Theme	Question (English)	Question (Spanish)
1A	Usefulness	I think learning about the science of "how learning happens/how people learn" would be very useful for educators.	Creo que sería útil para los/as educadores aprender la actual ciencia sobre "cómo sucede el aprendizaje / cómo aprende la gente".]
1B	Necessity	I think it is necessary for educators to understand the science of "how learning happens/how people learn" before learning about recommended teaching strategies (For example, to understand why something works and not just that it works).	Creo que es necesario para los educadores entender la ciencia detrás de "cómo sucede el aprendizaje / cómo aprenden las personas" antes de aprender las prácticas educativas recomendadas. (Por ejemplo, para entender por qué algo funciona y no solo lo que funciona).
1C	Requirement	A course on the science of "how learning happens/how people learn" (e.g. cognitive and biological processes that underlie learning) should be mandatory in initial teacher education.	Un curso sobre la ciencia de "cómo sucede el aprendizaje / cómo aprende la gente" (por ejemplo, los procesos cognitivos y biológicos que subyacen al aprendizaje) debería ser requerido en la formación docente.
1D	Sufficient formation	I feel I have received sufficient schooling on the science of "how learning happens/how people learn"	Siento que he recibido suficiente formación sobre la ciencia de "cómo sucede el aprendizaje / cómo aprende la gente"
1E	Confidence	I am confident in my knowledge of the science of "how learning happens/how people learn". E.g. I would feel confident teaching it to a peer.	Estoy confiado/a sobre mi conocimiento de "cómo sucede el aprendizaje / cómo aprende la gente". (Por ejemplo, me siento seguro/a enseñándolo a un colega.)
1F	Teaching practice alignment	I think my teaching practices are aligned with the scientific literature on "how learning happens/how people learn." (For example, I teach and design lessons in a manner that is consistent with the literature on learning.)	Creo que mis prácticas docentes están alineadas con la literatura científica sobre "cómo sucede el aprendizaje / cómo aprenden las personas" (por ejemplo, enseño y diseño lecciones de manera coherente con la literatura científica sobre "cómo sucede el aprendizaje / cómo las personas aprenden.)]

3.2. TABLE 2

Table 2. Post-survey questions

ID	Theme	Question (English)	Question (Spanish)
2A	Workshop usefulness	The workshop is useful for educators.	El taller es útil para educadores.
2B	Application clarity	It is clear to me how to apply what I learned to my teaching practice.	Veo claro que puedo aplicar lo que aprendí a mi práctica docente.
2C	Requirement	A course on the science of “how learning happens/how people learn” (e.g. cognitive and biological processes that underlie learning) should be mandatory in initial teacher education.	Un curso sobre la ciencia de "cómo sucede el aprendizaje / cómo aprende la gente" (por ejemplo, los procesos cognitivos y biológicos que subyacen al aprendizaje) debería ser requerido en la formación docente.
2D	Necessity	I think it is necessary for educators to understand the science of “how learning happens/how people learn” before learning about recommended teaching strategies (For example, to understand why something works and not just that it works).	Creo que es necesario para los educadores entender la ciencia detrás de "cómo sucede el aprendizaje / cómo aprenden las personas" antes de aprender las prácticas educativas recomendadas. (Por ejemplo, para entender por qué algo funciona y no solo lo que funciona).
2E	Confidence	I am confident in my knowledge of the science of “how learning happens/how people learn”. E.g. I would feel confident teaching it to a peer.	Estoy confiado/a sobre mi conocimiento de "cómo sucede el aprendizaje / cómo aprende la gente". (Por ejemplo, me siento seguro/a enseñándolo a un colega.)
2F	Teaching practice alignment	I think my teaching practices are aligned with the scientific literature on “how learning happens/how people learn.” (For example, I teach and design lessons in a manner that is consistent with the literature on learning.)	Creo que mis prácticas docentes están alineadas con la literatura científica sobre "cómo sucede el aprendizaje / cómo aprenden las personas" (por ejemplo, enseño y diseño lecciones de manera coherente con la literatura científica sobre "cómo sucede el aprendizaje / cómo las personas aprenden.)]

3.3. TABLE 3

Table 3. Study Participants

Group	Description
1	Pre-service teachers enrolled in a public university's teachers' education programme for high school teachers
2	In-service teachers at a public high school in Barcelona
3	In-service teachers at a semi-private school in the surroundings of Barcelona (includes high and vocational school)
4	In-service teachers at a semi-private school in a rural setting (includes elementary, high and vocational school)

3.4. TABLE 4

Table 4. Survey Responses

Question	Theme	Group 1	Group 2	Group 3	Group 4	In-service Total
1A	Usefulness	22	32	16	25	73
1B	Necessity	22	32	16	25	73
1C	Requirement	22	0	16	25	41
1D	Sufficient formation	22	0	16	25	41
1E	Confidence	22	32	16	25	73
1F	Teaching practice alignment	22	0	16	25	41
2A	Workshop usefulness	24	21	13	18	52
2B	Application clarity	24	0	13	18	31
2C	Requirement	24	17	13	18	48
2D	Necessity	24	21	13	18	52
2E	Confidence	24	0	13	18	31
2F	Teaching practice alignment	24	0	13	18	31

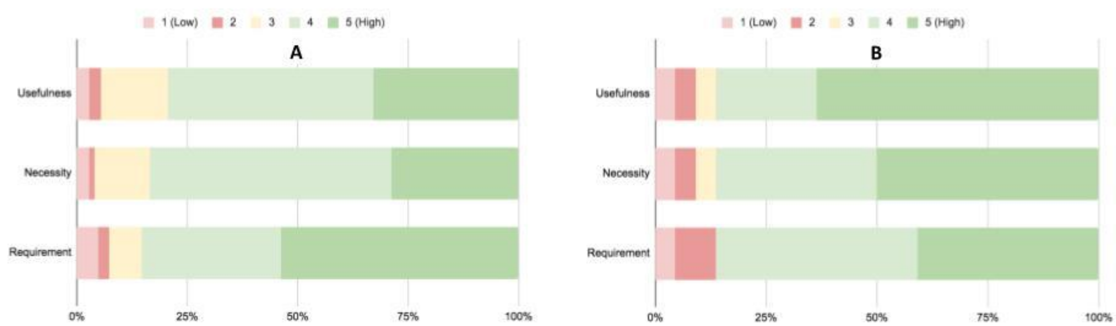
3.5. FIGURE 1

Figure 1. Schema of the 2.5-hour workshop on the Science of Learning

Introduction the Science of Learning	- Spaced Learning methodology
Part 1 Learning & memory	- Adaptive behaviour - The role of our memory system - Processing information in our memory system
Part 2 How does learning happen	- Neuroplasticity - Synaptogenesis, long-term potentiation, myelination - Stages of memory formation
Part 3 Barriers to learning	- Working memory - Attention - Retrieval routes - Prior knowledge
Recap Connecting to teaching strategies	- Managing attention - Visual organization of information - Retrieval practice

3.6. FIGURE 2

Figure 2. Pre-service (A) and In-service (B) teacher beliefs about the utility of the science of learning



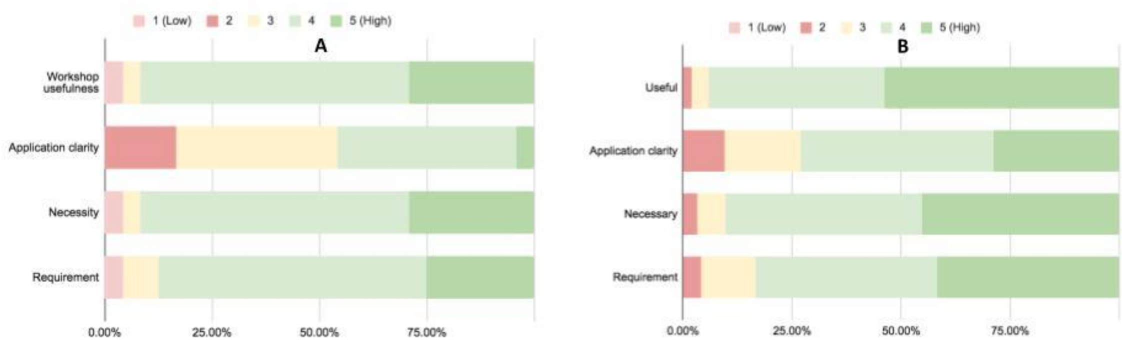
3.7.

3.8. FIGURE 3

Figure 3. Pre-service (A) and In-service (B) teacher self-assessments of knowledge

3.9. FIGURE 4

Figure 4. Pre-service (A) and In-service (B) teacher workshop evaluations



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