Where Are We Now? Research Trends in the Learning Sciences

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Abstract: Towards gaining a better understanding of the field of the Learning Sciences, this research investigates the research trends over 10 years. It also compares the Learning Sciences with the closely related academic fields of Educational Technology and Educational Psychology. A content analysis is performed on 5187 journal articles drawing from 12 top journals from 2003 to 2012. This content analysis was semi-automated and guided by an initial theoretical frame. The results reveal that research trends in the Learning Sciences have remained largely consistent except in the area of individual differences and affect, which has increased over the years. Key strengths of Learning Sciences include research on small group learning, inquiry, problem solving, argumentation, and mixed-methods. As the LS reflects on its state of practice, it should recognize that the field has achieved many research distinctives, yet, there are several opportunities for further research growth.

Introduction

The field of the Learning Sciences (LS) has evolved and blossomed internationally. It counts over 24 courses and programs around the world (NAPLeS). Over the past decade, new research topics and themes have emerged in the field including design studies, scaffolding, case-based reasoning, prior knowledge, and metacognition (Kolodner, 2004; Sawyer, 2008). LS researchers have been working closely with educators in schools, exploring new models of schooling, making explicit learning processes, as well as designing new methodologies and technologies to enable enhanced learning. As part of tracing its development and process, and enhancing its progress in the future, it is important to step back and reflect on the state of the field. Where are we now? What has been the focus of the LS? Are there certain research themes that have been dominating? What are the strengths and weaknesses of the field?

To gain some insight into the research trends of the LS, it is useful to compare it with related fields. The Learning Sciences draws from a wide spectrum of disciplines such as Cognitive Science, Educational Technology (ET), Educational Psychology (EP), Computer Science, and Applied Linguistics. The fields of ET and EP share a special bond with the LS as they all emphasize some aspect of learning. ET focuses more on the medium which learning occurs while EP, what occurs within the learner. It would be interesting to know whether they are differences between the LS and these two fields. Important distinctions could be drawn from the comparison, and theoretical and empirical contributions of the LS made explicit.

Moreover, in the field of the LS, there have been limited studies on its research trends. Several researchers have provided conceptual viewpoints of the state of the field. For instance, Sawyer (2008) synthesized four findings of LS research: 1) importance of deep conceptual understanding, 2) importance of learning connected and coherent knowledge, 3) learning authentic knowledge, and 4) collaboration. Besides conceptual viewpoints and insightful commentary, a useful method to examine the state of the field is through examining the corpus of articles published in the field.

Past research has examined published research trends through content analysis (Chang, Chang, & Tseng, 2010; Hew, Kale, & Kim, 2007; Hsu et al., 2012; Lee, Wu, & Tsai, 2009). The content analysis is usually conducted by categorizing journal articles in multiple dimensions. This is typically developed on the basis of literature reviews and/or a preliminary data analysis. For instance, Mitchell and McConnell III (2012) analyzed articles published in Contemporary Educational Psychology from 1995 to 2010 in terms of research topics, theoretical perspectives, research participants, and research methods. In addition, Hew, Kale, and Kim (2007) analyzed articles published in three journals related to ET from 2000 to 2004 in terms of research topics, research methods, data collection, and research settings.

Besides human content analysis, semi-automatic approaches to content analysis using text analytic software has been shown to be a viable method. These are more reliable than human coding and are relatively time-efficient (McKenny, Short, & Payne, 2012; Rotgans, 2012; Yu, Jannasch-Pennell, & DiGangi, 2011). For instance, Rotgans (2012) used semi-automatic content analysis to examine the trends of 10,168 articles in medical education research over 23 years. The research showed the viability of this approach and generated important themes useful for widening the scope of medical education research.

Through content analysis, we can identify what research topics, methods, research settings etc., are most frequently used in research articles and how their frequency has changed during a particular time period. For instance, Hew and colleagues (2007) found that articles about media study (41%) and psychology of learning (41%) are most frequently published in three ET journals from 2000 and 2004. Lee et al. (2009) found

that articles about student learning contexts were more published in three science education journals during 2003-2007 than during 1998-2002. Similarly, Rotgans (2012) found that there has been an increase in articles on communication skills training, clinical reasoning, faculty development, use of simulations, and student characteristics in six medical education journals from 1988 to 2010.

Towards gaining a better understanding of the field of the Learning Sciences, this research asks, what are the trends in LS over 10 years from 2003 to 2012? Secondly, how do these trends in LS differ from those in ET and EP? A research trend is the general direction that a field is heading towards. Trends will be identified by content analysis. A content analysis is performed on a dataset drawing from 12 top journals from 2003 to 2012. The quantity of articles that represent the research subtheme provides indication of the trends. This content analysis was semi-automated and guided by an initial theoretical frame of themes used in past research. The next section describes the methodology followed by the description of the results. A discussion of the findings is elaborated on and then integrated towards the end of the paper.

Method

Data Source

Journal article data from 2003 to 2012 was obtained from the Thomson Reuters Web of Science database. We selected four journals from each of the academic fields, LS, EP, ET. The twelve journals (refer to Table 1) are the journals with the highest impact factor in the three fields. We collected bibliometric information from original articles and excluded editorial materials, book and software reviews, and announcements. In total, 5187 journal articles were retrieved. Table 1 shows the breakdown of the papers from each journal. The International Journal of Computer-Supported Collaborative Learning was launched in 2006, although other LS journals regularly published articles from 2003 to 2007.

Table 1: Number of articles from the 12 Journals in the three fields

Field	Journal	No. of papers
Learning Sciences	(a) Journal of the Learning Sciences	140
	(b) International Journal of Computer-Supported Collaborative Learning	148
	(c) Cognition & Instruction	131
	(d) Instructional Science	290
Educational Psychology	(a) Educational Psychologist	186
	(b) Journal of Educational Psychology	657
	(c) Learning and Instruction	410
	(d) Contemporary Educational Psychology	270
Educational Technology	(a) Computers & Education	1502
	(b) Journal of Computer Assisted Learning	417
	(c) British Journal of Educational Technology	676
	(d) Educational Technology Research & Development	360

Analysis Method

All article titles, keywords and abstracts of the dataset were extracted and analyzed by semi-automated content analysis using the SPSS Text Analysis for Surveys 4.0 software. This software uses advanced linguistic algorithms to extract and classify key concepts from the text (IBM, 2011). The technology identifies the phrase, sentence and grammatical structures of content based on three main linguistic techniques: term derivation, term inclusion, and semantic networks. Based on pre-defined library rules, keywords and phrases are identified and grouped under a main concept. These concepts are then grouped into type patterns using semantic network techniques. For instance, the root concept “scaffolding” included related phrases and patterns such as “written scaffolds”, “peer scaffolding”, “computerized scaffolds + supported”, “scaffolding + effective” and “scaffolding approaches”.

One key advantage is that this technology allows researchers to extract and categorize key concepts reliably and consistently. It also reduces the time taken to categorize the content. However, human content analysis was still performed. Text analysis is an iterative process and extraction results were reviewed by the researchers according to the context of the text data. Categories were drawn from the data as well as derived from themes of past research. A preliminary data analysis of past content analysis frameworks revealed the following themes in Table 2. Based on this initial framework, relevant extracted concepts were identified. In addition, concepts that appeared frequently in the dataset were considered and fine-tuned as themes where possible.

Table 2: Initial Content Analysis Framework

Themes	Subthemes	Reference
Research topics	(a) Individual differences	Hew et al. (2007)
	(b) Learning processes	Hsu et al. (2012)
	(c) Instructional design and strategy	Lee et al. (2009)
	(d) Media study	Mitchell & McConnell III (2012)
	(e) Culture and community	
	(f) Research and evaluation methodology	
Research methods	(a) Quantitative	Hew et al. (2007)
	(b) Qualitative	Lee et al. (2009)
	(c) Mixed-methods	Mitchell & McConnell III (2012)
	(d) Review and meta-analysis	
	(e) Theoretical	
Research settings (participants)	(a) Laboratory	Hew et al. (2007)
	(b) Early childhood education	Hsu et al. (2012)
	(c) Primary school	Mitchell & McConnell III (2012)
	(d) Secondary school	
	(e) Higher education	
	(f) Informal context	
	(g) Virtual environment	

In total, from 5187 records, 1775 concepts were extracted. To better answer the two research questions of this study, we manually refined the software-generated categories by deleting irrelevant keywords, adding in new categories, editing the acceptable ones, and regrouping them. For example, the extracted data showed several articles focusing on "parent and family". We decided to identify this as our subtheme and included relevant extracted concepts such as "parent", "parental involvement", "father", and "mother". After the refinement process, 9 meaningful themes and 62 subthemes (subcategories) resulted. This formed the basis for further analysis.

From the SPSS Text Analysis for Surveys 4.0 software, a frequency count was generated. This denotes the number of articles that are classified into the subtheme. Even if an article has more than one extracted concept classified in that subtheme, it is only counted once. There are no extra counts of the same article in one subtheme. These larger themes were ordered by frequency from the highest to lowest. The results were then exported into SPSS Statistics 21 for further statistical analysis. For each subtheme, a series of three-way analysis of variance (ANOVA) was conducted to compare the paper counts for ET, EP and LS from 2003-2012. Whenever significant ANOVA results were obtained, Scheffe post-hoc test was conducted to compare the difference in paper counts between pairs of academic fields. To examine the trends over 10 years, we decided to use a ballpark period of 5-years to distinguish between earlier and later years, similar to Hsu et al. (2012). We conducted a series of t-tests to compare the paper counts for each subtheme of LS between period 1 (2003-2007) and period 2 (2008-2012). This process of refinement and analysis was similar to the steps by Rotgans (2012). Next, we examine the results of how themes changed over time (5-year interval) in the LS as well as how the themes were represented in the three academic fields.

Findings and Discussion

Table 3 below summarizes the results of the content analysis of the titles, keywords and abstracts of 12 journals from 2003-2012. This is ranked starting from the highest frequency count of the themes from the whole dataset.

Overall in the 3 fields, many of the articles fall into the theme of *research topics*, with 8232 articles examining a diversity of research topics from *media study* to *work and career*. Sociocultural practices such as *learning communities*, *culture* and *society* are also part of this theme of research topics. Within all the subthemes, there is a dominant subtheme on *media study*, with 3242 (62.5%) articles from the dataset. This is not surprising as various media forms from mobile devices to asynchronous discussion forums have been hot topics over the years in LS, ET and EP. This is similar to the findings by Hew et al. (2007). The subtheme of *student* in the category s*takeholder* is the second most examined area. The student being the main stakeholder in education research was found in 3108 studies (59.92%). At the tail end, there were fewer studies on *principal and leadership* among three fields (48 articles). This perhaps is due to the focus on the learner and the student in these education journals.

In the field of the LS, the *student* stakeholder is a primary focus. There were 478 articles or 67.42% of LS articles representing the student. Another major subtheme is that of *learning*, one of the educational activities. This was found in 348 (49.08%) articles. *Media study* was a close third, with 342 articles (48.24%) examining it. As for the tail end, *algorithms* were hardly examined, as just 1 article was identified. This is not surprising in LS as the focus is not on computer-related algorithms. *Principal & leadership* was also less of a focus, with 4 articles (0.56%) about it. This is an area of concern as school leaders can determine several

sociocultural practices in schools. In addition, *society* was a research topic that was hardly emphasized in LS with only 6 identified articles (0.85%). This is a surprising find as *society* provides a key context in the design and practice of learning. These infrequently covered subthemes highlight possible gaps in LS research.

Table 3: Result of the content analysis of the titles, keywords and abstracts of 12 journals from 2003-2012

Themes and subthemes	Comparison within LS[a]		Comparison among ET, EP, and LS			
	LS 2003-2007 (n=268)	LS 2008-2012 (n=441)	ET 2003-2012 (n=2955)	EP 2003-2012 (n=1523)	LS 2003-2012 (n=709)	Post-hoc tests[b]
1. Research Topics						
Media study	122(46%)	220(50%)	2655(90%)	245(16%)	342(48%)	ET>LS*, EP>ET*, ET≈LS
Academic achievement	19(7%)	38(9%)	242(8%)	472(31%)	57(8%)	EP>ET*, EP>LS*, ET≈LS
Learning environment	26(10%)	46(10%)	577(20%)	59(4%)	72(10%)	ET>LS*, ET>EP*, EP≈LS
Individual differences	7(3%)	26*(6%)	220(7%)	303(20%)	33(5%)	EP>ET*, EP>LS*, ET≈LS
Evaluation	13(5%)	28(6%)	470(16%)	40(3%)	41(6%)	ET>LS*, ET>EP*, EP≈LS
Learning strategies	11(4%)	24(5%)	359(12%)	94(6%)	35(5%)	ET>EP*, ET>LS*, EP≈LS
Memory	19(7%)	19(4%)	80(3%)	202(13%)	38(5%)	EP>LS>ET*
Learning outcomes	14(5%)	30(7%)	220(7%)	52(3%)	44(6%)	ET>EP*, LS>EP*, ET≈LS
Learning communities	19(7%)	32(7%)	217(7%)	22(1%)	51(7%)	LS>EP*, ET>EP*, ET≈LS
Curriculum	23(9%)	25(6%)	153(5%)	25(2%)	48(7%)	LS>EP*, ET>EP*, ET≈LS
Learning processes	9(3%)	23(5%)	133(5%)	30(2%)	32(5%)	LS>EP*, ET>EP*, ET≈LS
Culture	13(5%)	18(4%)	106(4%)	51(3%)	31(4%)	LS≈EP≈ET
Professional development	8(3%)	14(3%)	106(4%)	22(1%)	22(3%)	ET>EP*, EP≈LS, ET≈LS
Society	4(1%)	2(0%)	89(3%)	25(2%)	6(1%)	ET>LS*, ET>EP*, EP≈LS
Work and career	2(1%)	6(1%)	65(2%)	38(2%)	8(1%)	LS≈EP≈ET
2. Domains of Learning						
Knowledge	107(40%)	43(10%)	585(20%)	381(25%)	300(42%)	LS>ET*, EP>ET*, EP≈LS
Motivation	21(8%)	47(11%)	423(14%)	460(30%)	68(10%)	EP>ET*, EP>LS*, ET≈LS
Cognitive	61(23%)	95(22%)	333(11%)	368(24%)	156(22%)	LS>ET*, EP>ET*, EP≈LS
Skills	27(10%)	55(12%)	327(11%)	278(18%)	82(12%)	EP>ET*, EP>LS*, ET≈LS
Attitudes	10(4%)	19(4%)	315(11%)	69(5%)	29(4%)	ET>EP*, ET>LS*, EP≈LS
Beliefs	26(10%)	43(10%)	129(4%)	198(13%)	69(10%)	EP>LS>ET*
Affect	4(0.01%)	22*(5%)	178(6%)	148(10%)	26(4%)	EP>ET*, EP>LS*, ET≈LS
Metacognitive	12(4%)	21(5%)	62(2%)	82(5%)	33(5%)	LS>ET*, EP>ET*, EP≈LS
3. Stakeholder						
Student	176(66%)	302(68%)	1733(59%)	897(59%)	478(67%)	LS>EP*, LS>ET*, EP≈ET
Teacher	64(24%)	114(26%)	732(25%)	307(20%)	178(25%)	LS>EP*, ET>EP*, ET≈LS
Parent & family	3(1%)	6(1%)	66(2%)	112(7%)	9(1%)	EP>ET*, EP>LS*, ET≈LS
Pre-service teacher	6(2%)	15(3%)	127(4%)	23(2%)	21(3%)	ET>EP*, ET≈LS, EP≈LS
Policy-maker	5(2%)	5(1%)	109(4%)	16(1%)	10(1%)	ET>LS*, ET>EP*, EP≈LS
Principals & leadership	1(0%)	3(1%)	38(1%)	6(0%)	4(1%)	ET>EP*, ET≈LS, EP≈LS
4. Educational Activities						
Learning	134(50%)	214(49%)	1378(47%)	395(26%)	348(49%)	ET>EP*, LS>EP*, ET≈LS
Teaching	111(41%)	170(39%)	1196(40%)	413(27%)	281(40%)	ET>EP*, LS>EP*, ET≈LS
Assessing	19(7%)	19(4%)	261(9%)	68(4%)	38(5%)	ET>LS*, ET>EP*, EP≈LS
5. Research Settings (Participants)						
Higher education	45(17%)	75(17%)	826(28%)	255(17%)	120(17%)	ET>EP*, ET>LS*, EP≈LS
Secondary school	36(13%)	48(11%)	296(10%)	255(17%)	84(12%)	EP>ET*, EP>LS*, ET≈LS
Virtual environment	16(6%)	19(4%)	420(14%)	9(1%)	35(5%)	ET>LS>EP*
Primary school	11(4%)	25(6%)	250(8%)	134(9%)	36(5%)	EP>LS*, ET>LS*, EP≈ET
Early childhood	8(3%)	15(3%)	47(2%)	182(12%)	23(3%)	EP>ET*, EP>LS*, ET≈LS
Informal context	6(2%)	12(3%)	53(2%)	11(1%)	18(3%)	ET>EP*, LS>EP*, ET≈LS
6. Pedagogical Strategies						
Collaboration	69(26%)	134(30%)	556(19%)	61(4%)	203(29%)	LS>ET>EP*
Feedback	9(3%)	19(4%)	173(6%)	67(4%)	28(4%)	LS≈EP≈ET
Games	4(1%)	11(2%)	190(6%)	9(1%)	15(2%)	ET>LS*, ET>EP*, EP≈LS
Inquiry	33(12%)	54(12%)	85(3%)	36(2%)	87(12%)	LS>ET*, LS>EP*, EP≈ET
Simulation	9(3%)	15(3%)	155(5%)	12(1%)	24(3%)	LS>EP*, ET>EP*, ET≈LS
Small group learning	17(6%)	40(9%)	85(3%)	37(2%)	57(8%)	LS>ET*, LS>EP*, EP≈ET
Scaffolding	26(10%)	31(7%)	93(3%)	19(1%)	57(8%)	LS>ET>EP*
Reflection	10(4%)	16(4%)	102(3%)	20(1%)	26(4%)	LS>EP*, ET>EP*, ET≈LS

Themes and subthemes	Comparison within LS[a]		Comparison among ET, EP, and LS			
	LS 2003-2007 (n=268)	LS 2008-2012 (n=441)	ET 2003-2012 (n=2955)	EP 2003-2012 (n=1523)	LS 2003-2012 (n=709)	Post-hoc tests[b]
Argumentation	17(6%)	27(6%)	35(1%)	36(2%)	44(6%)	LS>EP>ET*
Modeling	8(3%)	10(2%)	66(2%)	28(2%)	18(3%)	LS≈EP≈ET
Problem solving	8(3%)	14(3%)	49(2%)	12(1%)	22(3%)	LS>ET*, LS>EP*, EP≈ET
Didactic teaching	3(1%)	6(1%)	51(2%)	16(1%)	9(1%)	LS≈EP≈ET
7. Research Method						
Quantitative	47(18%)	103(23%)	494(17%)	471(31%)	150(21%)	EP>LS>ET*
Qualitative	47(18%)	76(17%)	364(12%)	33(2%)	123(17%)	LS>ET>EP*
Theoretical, conceptual	23(9%)	34(8%)	195(7%)	57(4%)	57(8%)	LS>EP*, ET>EP*, ET≈LS
Mixed-methods	22(8%)	26(6%)	127(4%)	28(2%)	48(7%)	LS>ET>EP*
Review and meta-analysis	2(1%)	9(2%)	52(2%)	63(4%)	11(2%)	EP>ET*, EP>LS*, ET≈LS
Algorithms	0(0%)	1(0%)	65(2%)	7(0%)	1(0%)	ET>EP*, ET>LS*, EP≈LS
8. Epistemic Disciplines						
Science	65(24%)	135(31%)	311(11%)	182(12%)	200(28%)	LS>EP*, LS>ET*, EP≈ET
Mathematics	52(19%)	82(19%)	173(6%)	291(19%)	134(19%)	LS>ET*, EP>ET*, EP≈LS
Language	20(7%)	37(8%)	219(7%)	309(20%)	57(8%)	EP>ET*, EP>LS*, ET≈LS
9. Age of Learner						
Children	30(11%)	48(11%)	241(8%)	503(33%)	78(11%)	EP>ET*, EP>LS*, ET≈LS
Adult & lifelong learners	8(3%)	10(2%)	170(6%)	66(4%)	18(3%)	ET>LS*, EP≈ET, LS≈EP
Teenagers	3(1%)	9(2%)	38(1%)	149(10%)	12(2%)	EP>ET*, EP>LS*, ET≈LS

Note: [a]Only *p* values for the statistically significant *t*-test results were indicated for the comparison of LS paper counts for earlier years (2003-2007) and later years (2008-2012); [b]Results of Scheffe post-hoc test after significant results of a three-way analysis of variance was found on paper counts for the period 2003-2012; *p<.05.

What Are the Trends in LS over Ten Years (2003-2012)?

Overall, there were not many thematic differences between the earlier and later years of LS. The data revealed 2 significant differences in subthemes over the 2 stages. Development of the field of the LS over the 2 stages shows an emphasis on *individual differences* such as gender, learning styles, and age. As seen from Figure 1, there is a sharp increase of *individual differences* research compared to those of *evaluation* and *learning strategies* among the research topics. This suggests the recognition in the LS to examine sociocultural and larger contextual factors that affect learning.

Another finding is regarding *affect*, which examines feelings, moods, and emotions. This is increasingly focused on in the later years of LS. This suggests a broadening in the LS towards the understanding of the domains of learning. As illustrated in Figure 2, *cognitive* and *psychomotor (skill)* aspects are still frequently studied in the LS as compared to *affect*. However, the field has recognized the importance of the socioemotional aspects of learning too. We note that there seems to be a slight dip in the *cognitive* aspects of learning and this research area could be reaching a saturation point.

Nevertheless, the number of articles focusing on particular themes has been steadily increasing over the years. It suggests that, the LS as a field, is sticking to its roots. The next section helps us understand the LS research trends in relation to the closely related fields of EP and ET.

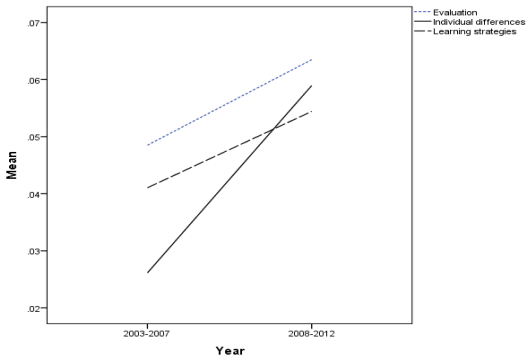

Figure 1. Trends in research topics

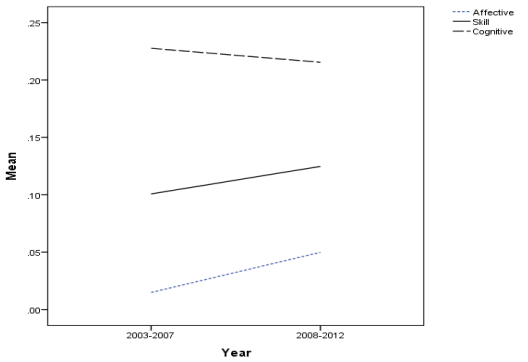

Figure 2. Domains of learning: affect, skill and cognitive

How Does LS Research Differ from EP and ET Research?

The results reveal many significant differences between LS, EP and ET. These differences highlight the strengths and weaknesses of each field. We examine the research topic first. Interestingly, the findings reveal that the LS does not dominate any particular research topic. The LS is similar to ET but stronger than EP in terms of *learning outcomes, learning communities, curriculum,* and *learning processes.* Focusing on learning end goals, being in learning communities of practice, designing the curriculum, and understanding processes of learning all suggest that the LS concerns itself very much in the practice of learning.

As for domains of learning, LS has focused more on *knowledge, cognitive*, and *metacognitive* aspects as compared to ET but similar to EP. In the LS, there is a clear emphasis on *knowledge* as seen from the many studies on knowledge building, knowledge creation and even knowledge transfer. As for *cognitive* and *metacognitive* aspects, these acknowledge LS's close ties with the Cognitive Sciences. It highlights the depth to which the LS explores learning, making visible thinking about thinking.

The LS holds *students* as their chief stakeholders, much more than the other 2 fields. Learning scientists seem to place importance on their students for it is them who are performing the learning. LS also emphasizes on *teachers* more than EP but similar to ET. This could be due to the tight interplay between teaching and learning in LS. What and how teachers teach affects how students learn. In ET teachers are important stakeholders too as they have certain control over the technologies that students use. LS and EP generally tend to emphasize naturalistic settings, where the classroom or course is the research setting and the teacher and student are the participants. However in EP, there is less emphasis on students and teachers as compared to the other fields possibly owing to their focus on laboratory testing with experiment subjects.

For educational activities, LS's strength is in *learning* and *teaching* but not *assessing*. There are a greater proportion of articles in LS on *learning* and *teaching* compared to EP as shown in Figure 3. This highlights the strong tradition in LS on these activities that directly contribute to enhancement of learning. *Assessing* is less emphasized in LS and suggests research opportunities in this area. Assessing is stronger in ET possibly due to the design and development of electronic forms of assessment.

In research setting, the LS has emphasized research on *informal contexts* and *virtual environment* as compared to EP. This is similar to ET. These highlights the many sociocultural understandings of learning, that it is not limited to the formal environment but to the informal and virtual contexts. Moreover, technological tools help to advance learning in these research settings. Interestingly, the other two fields have a larger proportion of articles on *primary school* research settings as compared to LS. EP also dominates the other two fields in *early childhood* settings suggesting a de-emphasis in the LS on these research participants.

In the 9th category, *age of learner*, a similar pattern emerges as EP dominates LS in terms of *children* and *teenagers*. It is possible that EP researchers with expertise in developmental psychology have carried out more research about individual differences in the development of children when compared to LS researchers. This suggests a gap in LS research for younger learners and LS researchers could delve into this area. As for pedagogical strategies, the LS shows its dominance in many different strategies*: collaboration, small group learning, inquiry, problem solving, argumentation,* and *scaffolding*. As can be expected, *collaboration* is a key

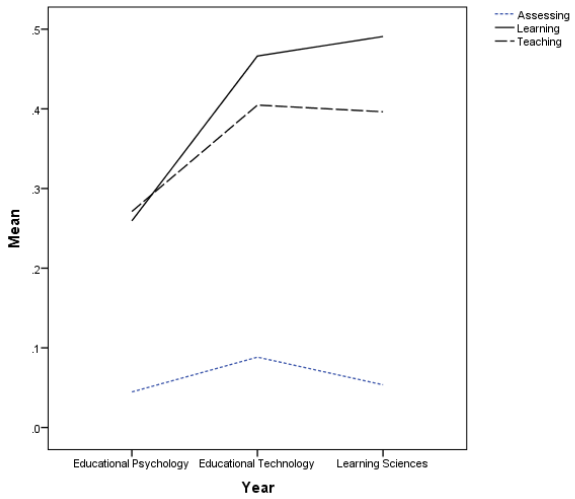

Figure 3. Educational activities among the three fields

focus in the LS. A journal on collaborative learning was specially launched. Similarly, the focus on *small group learning* is seen in LS compared to the other 2 fields. The *inquiry* approach is also a key strength of LS research.

The LS focuses much more on inquiry compared to ET or EP. This particular pedagogy systematizes how students discover and retrieve information. Entire curriculums have been developed around such pedagogies.

Problem solving, in particular real-world problem solving is another hallmark of the LS. Many curricular tasks are designed with problem solving as the basis to encourage students' reasoning, communication, and explanation skills. Many learning interventions in LS are centered on such problem-based learning approaches. *Argumentation* too has been clearly articulated in the LS with many LS scholars synthesizing the many steps and processes of such pedagogy. Another key strength of the LS is the subtheme *scaffolding*. The LS has a strong foundation of work on scaffolding compared to the other two fields. There have been many different theoretical developments of scaffolds from metacognitive ones to fading scaffolds and this pedagogical strategy has certainly contributed theoretically and practically to the field (McNeill, Lizotte, Krajcik, & Marx, 2006).

In terms of research method, *qualitative* and *mixed-methods* are more dominant in LS compared to EP and ET. This reinforces the field's desire for richness in insights and in-the-field design interventions. However, further opportunities exist for *reviews and meta-analysis*, which seems to be stronger in EP.

As for epistemic disciplines, *science* is the dominant discipline in LS. *Mathematics* is also emphasized more in LS compared to ET. However, *language* research is still a particular focus of EP as compared to LS. This could be an area that more LS researchers could go into.

Concluding Remarks

Where are we now? This paper has revealed data-driven research trends in LS over 10 years, as well as in comparison with ET and EP. The LS in these 10 years has remained rather consistent in research focus. Still, there is evidence of incremental changes in research themes, particularly in *individual differences* and *affect*. The increasing focus on *affect* is similar to the trend in science education research (Lee et al. 2009) which looked at the affective dimensions of science learning. It is also surprising that subthemes related to sociocultural practices have not increased significantly across the stages. Although many LS researchers agree that novel pedagogical strategies should be investigated in real contexts, it is hard to examine the roles of sociocultural factors in learning and teaching practices as well as learning outcomes. More LS research should explore dynamic interactions between individual learning activities and sociocultural characteristics of a community and develop new learning theories.

The comparison of LS with ET and EP reveals several distinctions of the LS. The LS has clear distinctives in the student as learner, pedagogical strategies: *collaboration, small group learning, inquiry, problem solving, argumentation,* and *scaffolding.* These lines of research should be continuously studied and capitalized on. Our data also reveals the dominance of LS in the epistemic discipline of *science*. As compared to EP, the LS has a greater emphasis on the research topics: *learning outcomes, learning communities, curriculum,* and *learning processes* and has focused on educational activities *learning* and *teaching* in *informal contexts* and *virtual environments*. As compared to ET, the LS is more dominant in the learning domains *knowledge, cognition* and *metacognition* and the epistemic discipline *mathematics*. Other strengths of the LS include its methodologies in *qualitative* and *mixed-methods*. It is important that LS as a new research field has unique topics, concepts, and theories, which are distinguishable from EP and ET.

We believe that there are areas for growth in LS. Research on assessment is an area of growth and there are some past LS research that has examined *assessment* for deeper understanding (Sawyer, 2008). Another topic that LS could focus on relates to *societal* aspects. Past LS has been very much classroom-based, but ecological and systemic perspectives could enlighten how LS work can be seen in a broader lens, and would have further implications at policy and societal levels. As mentioned, LS has been increasing in *affect* research over the 10 years. This is a good sign, as compared to the other 2 fields, LS still lacks behind them. Greater emphasis of the affective aspects of learning would be fruitful for a holistic understanding of the learner. Moreover, LS researchers might want to diversify from *science* and *mathematics* epistemic disciplines to explore *languages*. Lastly, the LS should also place greater emphasis on younger learners such as those in early childhood education to allow for a more developmental understanding of the learner.

This research is not without its flaws. The findings reflect only 10 years of the selected journal articles, and may not be an extensive gauge of research trends. Another limitation relates to the method where articles are classified based on extracted concepts through pre-defined rules. Articles could have been classified into only 1 category. Similarly, this method did not allow for articles to be coded for each research theme. To mitigate this, the authors examined articles which fell into only one category and identified further concepts or patterns to classify it into other subthemes. Lastly, the themes and subthemes identified in the study were dependent on the extraction process. If certain keywords were not present, it was difficult for the software to recognize it. This posed difficulties when the authors wanted to examine less common trends such as "scaling and translation" and this was removed from the final subthemes. Another problem arose for overly frequently words such as "design". For instance, many abstracts used phrases such as "in the design of the study". Due to the lack of sophistication in the rules of extraction, these articles were also categorized into the subtheme

"design studies". As there were too many non-relevant articles included in this subtheme, the authors had to remove it in view of having more accurate subthemes. We acknowledge that these categorizations can be further refined. Nevertheless, the existing themes and subthemes do reveal important findings of the state of LS research.

LS has its key strengths in research ranging from *small group learning, inquiry, problem solving, argumentation* to *qualitative* and *mixed-methods*. These strengths can be further capitalized on and deepened. This paper has also identified research trends that could be further examined such as *assessing* and *affect*. In addition, this study's methodology has showcased a reliable and relatively time efficient method of content analysis which can be further built upon. As the LS reflects on its state of practice, it should recognize that the field has achieved many research distinctives, yet, there are several opportunities for further research growth.

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