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# Professional Learning from Disturbances in Healthcare: Managerialism and Compassion

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This study asks what behaviours might convert professional disturbances in maternity wards into opportunities for learning within healthcare and how that process is influenced by models of management and leadership. A framework of Cultural History Activity Theory helped to analyse moments of fractured collaboration in which uncertainty about roles and differences in professional status was a factor. Implications for professional learning are discussed along with the frames that might give coherence and utility to future research. We conclude that any interventions to support professional learning should reflect the broadly compassionate ethos that informs the commitments and activities of healthcare workers.

*Keywords:* leadership, compassion, managerialism, healthcare, maternity, cultural-historical activity theory.

## Introduction

There are few fields of work where professional and organisation performance are as important as front line medical services. Whereas organisations in other sectors can try new ideas from management studies in a spirit of experimentation, situations of life and death place people under an extraordinary obligation to avoid mistakes. The contribution of management as a practice and of management studies to the healthcare sector has been mixed. Since the 1990s, in many countries worldwide, concepts from the private sector have been brought into the public sector. This approach was called New Public Management (NPM) and proponents made the claim it would bring better outcomes for patients and the taxpayer (Schachter, 2014). Aside from introducing a new layer of cost to healthcare organisations, the impact of NPM is hotly debated, even amongst the management consultants and researchers who have made this agenda their professional focus (Schachter, 2014).

NPM can be understood as one branch of ‘managerialism’ – an ideology which ‘justifies the application of managerial techniques to all areas of society on the grounds of superior ideology, expert training, and the exclusive possession of managerial knowledge necessary to efficiently run corporations and societies’ (Klikauer, 2013, p. 1103). Overviews of evidence across sectors, sociologist Thomas Klikauer (2013) summarises the view that for many decades managerialism has been establishing the authority of management as a practice – and managers as practitioners – in ways that, often deliberately, undermine the power of owners, technically-focused employees, social activists and wider citizenry.

Within the healthcare sector, recent ideas on how to address the failings of NPM have echoed the romantic hopes of management theorists more widely. That is a turn towards the mythical role of ‘leadership.’ Perhaps its starkest expression in the British medical sector is this unqualified assertion: ‘Strong leadership is vital to effecting lasting organisational change’ (Amess & Tyndale-Biscoe, 2014, p. 6). Critical scholars of leadership have shown that most uses of the concept are based on untested assumptions about the salience of individuals with authority in a hierarchy and wish lists of personal professional qualities, which serve to distract attention from more meaningful analysis of organisational processes (Bendell et al., 2017). In healthcare that discourse of leadership has been given the name ‘leaderism’ (O’Reilly & Reed, 2010).

Maternity care in the UK is the focus of the research in this paper. Many texts in the literature of maternity care management reproduce uncritically the refrains of the current mainstream discourse of management and leadership (Amess & Tyndale-Biscoe, 2014; King’s Fund, 2014; Kirkup, 2015; Ralston, 2005; Warwick, 2015). One report on leadership in maternity services claims, with an assumption that no evidence is needed, that ‘there is no doubt amongst opinion formers and policy makers that leadership plays a significant part in the delivery of high-quality health care’ (Warwick, 2015, p. 2). The report goes on to describe the necessary leader as (we paraphrase): *adaptive, flexible, responsive, visionary, emotionally intelligent, motivating, inspiring, interactive, non-hierarchical, non-individualistic, listening, courageous, discontented (with the status quo), compelling, tenacious, patient, collaborative, innovative, enabling, open, honest and effective*. That is an unfeasible list of requirements and implies a form of leadership that miraculously cuts across prevailing institutional and professional forms of authority. If this is the form of leadership that impacts fundamentally on the provision of high-quality health services then we must seek it elsewhere than in a narrow range of professionally defined positions.

Contemporary discourses of management associated with NPM have disrupted older notions of professional authority, such as the role of Matron

in hospitals (Reed et al., 2004; Smith, 2008). The professional status of midwives (in relation to doctors, for instance) has developed slowly and the process is not complete; similarly, the status and function of Maternity Support Workers (MSWs) or maternity ‘assistants,’ a more recent role developed to support qualified professional midwives is contested and evolving and differs between countries. For example, the role of *kraamverzorgende* in the Netherlands, who assist midwives during the birth and support mothers afterwards, is more explicitly written into an ideology of childbirth than is that of MSWs in some other countries (Benoit et al., 2005). In the UK, where the research for this paper took place, The Royal College of Midwives (RCM) handbook for Maternity Support Workers states that ‘There is currently no single definition of the MSW role and a wide range of titles are used for particularly higher-level roles’ (2016). Elsewhere, the RCM admits that ‘[Studies, including King’s Fund, 2011] have noted the development of support workers in maternity services [. . .] can be ad hoc and inconsistent’ (2017). MSWs themselves have complained that they are disempowered in a maternity context by having had a generalist training (Sanders et al., 2015).

This situation of unclear and evolving professional roles and the challenge of NPM to prior bases for professional authority provides a context within which inter-personal disturbances could occur. Another context for our study is that of a UK National Health Service (NHS) subject to funding constraints as patient demand grows faster than budgets, leading to cuts in the number of frontline medical staff in many hospitals across the UK. Organisations facing such pressures are likely to experience more workplace disturbances (Borges et al., 2017).

The changing nature of roles and the pressure on resources means that professional learning by staff in the healthcare sector is important. The likelihood of disturbances at work means that how they are handled and learned from to improve both patient care and staff wellbeing is also a key issue. The mixed history of NPM provides an important context for management researchers interested in how healthcare could be improved. In our case, it led us to research how staff on maternity wards can learn from disturbances in the pursuit of good patient care and staff wellbeing. We consciously sought to avoid NPM-related tropes about leadership, management or training interventions, and instead to take our cues from those providing crucial care on a daily basis. The research examines disturbances in three maternity wards in the UK and draws out implications for professional learning (Boyd et al., 2014). We hope that this line of inquiry will lead to a better understanding of what behaviour will help turn such disturbances into actionable learning outcomes.

In the next section, we outline our methodology, before presenting vi-

gnettes of three workplace disturbances and our analysis of what they show in the context of how professional learning was occurring in the maternity wards. We explore ideas for how professional learning could be better supported. We conclude that a post-NPM and non-managerial approach to improving practices could be founded on solidarity with the innate compassion of healthcare workers, and support for them to develop their own competencies for compassionate communication with each other and their patients.

### **Methodology**

Our research and analysis is founded on theories of professional learning (Boyd et al., 2014) as well as Cultural Historical Activity Theory (CHAT). Central to Cultural Historical Activity Theory is the acceptance that the process of organising is 'ongoing, culturally and historically situated, materially and socially mediated' (Roth and Lee, 2007). An activity system has a subject and object, both mediated by material and social contexts, a system of functions and roles and a set of rules, norms and procedures (Engeström, 2001). One of the distinctive features of CHAT for our purposes is that it recognises that work practices are both developmental and inherent with inconsistency, paradox and tension (Engestrom & Lemos, 2016). In this way, it supports research that explores the complex, tentative developments taking place in professional health care work. Within this framework, a range of methods was employed, including ethnographic observations, interviews with a range of maternity staff and document analysis.

In our analysis, we have considered several other approaches including Practice Theory (Schatzki, 2001, 2006; Nicolini, 2012) and Discourse Analysis (Fairclough, 2001) each of which offers a way into the very broad questions: how do work practices evolve positively towards greater organisational efficacy and member satisfaction? What makes a disturbance disturbing to participants and how might disturbance affect that positive evolution?

The NHS Trust where the research was carried has been named 'Trust X' for the research purposes. The data was collected over 2 years from three maternity wards that collectively deliver over 2000 births a year. The subjects of the research were midwives and Maternity Support Workers (MSWs). In total 47 practitioners were interviewed (9 from 'Red Ward,' 22 from 'Blue Ward' and 16 from 'Green Ward'). Pseudonyms have been used throughout this paper for both the hospital wards and practitioner/patient names. The data generated from this research was coded with the use of constructs and principles from the Cultural Historical Activity Theory (CHAT). Firstly, the various aspects of CHAT such as the 'tools' 'rules' and 'object of activity' were identified in the data, and labelled. Any perceptible tensions



and disturbances in the data were also labelled and coded. Once an initial coding had been completed using the various CHAT constructs, a second and third round of data analysis was conducted, which involved further coding and grouping of the data using the CHAT terminology.

In this paper, we focus on an exploration of some of the disturbances that were observed in the data. These were identified as such either by the practitioners themselves or due to there being a problem either in the provision of medical care or in the emotional response of one of the medical staff. We examined why these disturbances manifested, and the impact on practitioners, before considering the implications of such disturbances for professional learning. We chose to frame these disturbances not as personal pathologies, but as expected dynamics in organisations that are undergoing some turbulence.

For this paper we have selected three particular disturbances from the range of data as they are illustrative of the emergent themes on professional learning. We then look more closely at these three disturbances and the professional learning they reflect, with a view to developing recommendations for interventions that could support such professional learning and enhanced practice in future.

## Findings

In the following sections, we present descriptive summaries of three disturbances that occurred during the research. Each is presented in relation to a form of learning that we chose to ascribe to it during analysis. The primary research was undertaken by the lead author of this paper, which is the reference to 'I' in the descriptions. Each disturbance involves Midwives and Maternity Support Workers (MSW) in the flow of maternity practice. Midwives are trained health-care professionals specialising in pregnancy, childbirth, postpartum and newborn care, they are members of the Nursing and Midwifery Council (NMC). Maternity Support Workers work under the supervision of a registered midwife providing care for women, their partners and babies. The ostensible intention of the NHS in recruiting increasing numbers of MSWs was to boost public health messaging, especially in promoting breastfeeding. MSWs themselves have been recorded expressing frustration that the training they had received was focused on the requirements of generic health care rather than the specifics of maternity care (Sanders et al., 2016). Informal observation during the fieldwork for this paper suggested that uncertainty on the part of midwives and MSWs about the nature and status of MSW competence may be a contributing factor to the disturbances described below. For easy reference in the subsequent discussion, the three disturbances have been given concise labels of 'collective learning'; 'reflective learning'; and 'emergency learning.'

**Collective Learning**

The first key finding to emerge from the research was the frequency of collective learning. In several scenarios, staff were observed developing collective insight and understanding through their interactions. The collective learning was often not explicit. Participants rather navigated their way through situations and learned together as events unfolded. The knowledge they acquired through such processes might not be developed through classroom-based learning methods.

The disturbance below covers a period of fieldwork from the early hours of a Thursday morning, around 3 am. The delivery suite was extremely busy and the midwives were under discernible pressure. Several women were reaching the culmination of labour at the same time and midwives were occupied in every delivery room. Only one maternity support worker was on duty and on this occasion, she was covering both the delivery suite and postnatal ward:

*Disturbance 1: 'Acting up'*

The doorbell rings and Debbie the maternity support worker rushes to answer it. A woman in a wheelchair is wheeled in by her partner, she's puffing and panting and she's telling Debbie she thinks she might need to push.

Debbie attempts a joke with her and tells her 'she's come to the right place then'!

Debbie takes hold of the wheelchair and quickly pushes the woman down the corridor onto the delivery ward.

A midwife who's scribbling some notes looks up, greets the woman and rushes to her side, tells her everything is going to be ok. Midwife 'nods' to Debbie and they push her promptly into one of the delivery rooms. In about twenty minutes or so the midwife emerges and tells me the woman had given birth to a boy.

Debbie had acted as the 'second person' in the delivery. Around an hour later Debbie is called from the office area into another delivery room to assist another midwife with the delivery. When the ward seems to settle down it's around 7 am. Debbie and I engage in some conversation about the shift as she makes toast for one of the women.

I ask how Debbie thinks the night has gone. Debbie tells me that she had really liked being so involved in the deliveries tonight, it's not often 'I get to catch the baby' she says let alone 'two in one night.' She tells me that when it is 'crazy like tonight they'll often need us (MSW's) in

with them.’ ‘You see’ she says, ‘When it’s going like a fairground they will let you do a lot more.’

I ask why that is and Debbie replies saying that whilst midwives always prefer another midwife to be in the room with them in case anything goes wrong, they (MSW’s) are officially allowed to act up as the second at birth if the situation requires it.

In the scenario above, the arrival of a woman (whose birth is impending) to an already busy ward creates an ‘urgent situation.’ Given the imminence of the birth and the lack of midwives available to help the midwife, Debbie’s involvement in the birth first seems to go unquestioned. Through prior experiential practice on the ward, Debbie has learnt what kinds of situations may require her involvement and that when the practice becomes extremely pressurised, her help is promptly required.

In this situation, Debbie learns the precise point in practice in which she could be called upon to assist the midwife, and the importance of her being on hand promptly to help with this pressurised situation. Through her experiencing the scenario, Debbie learns how the midwife will seek her help, either through ‘nodding’ as the woman enters the ward signalling Debbie’s assistance, or verbally asking for her help. Debbie’s involvement appears quite customary. However, after both deliveries, Debbie informs us that it only tends to be when the ward is exceptionally busy that midwives involve support workers in deliveries. On these situations, it is assumed acceptable for them to be involved with the labour, a task referred to as ‘acting up as the second midwife:’

It was a rough delivery so usually she would always prefer to have a midwife in with her rather than one of us acting up so we would tend to only be asked to help on those occasions when we are really short-staffed [. . .] In the last room, there was a shoulder distortion which I used to find terrifying but I have had to stay, cos there was no-one else. I knew exactly what she [the midwife] was asking me to do, and I could do it so it was fine; all was OK. I do feel much more confident about helping midwives with births the more I do. [Debbie, MSW]

Arguably, it is only because the situation is so pressurised that Debbie has the opportunity to ‘access’ the learning (Lave & Wenger, 1991). Had another midwife been available, Debbie would not have ‘had to stay’ and her learning about this challenging and complex birth would have been circumvented. However, as Debbie indicates, there was simply nobody else to support the midwife. By being given the opportunity to assist the midwife, Debbie’s confidence increases. There are two key points we wish to raise here. Firstly, it is because the situation is so tense that the midwife and

the MSW learn to work together in the moment to moment flow of practice. Disturbances and tensions are key sources of learning and transformation (Engeström, 2001). Secondly, only by jointly experiencing the same disturbance can collective learning ensue.

Collective learning is that which occurs between more than one practitioner in the maternity environment while addressing a problem (Laberge, 2006). When faced with a shoulder distortion, the midwife and the MSW develop collective insight and understanding. The midwife has learnt exactly what the MSW needs to do and can articulate this clearly to her. Likewise, the MSW also learnt how she can best support the midwife for the successful delivery of a child. That learning is not explicit, with participants navigating their way through situations and learn together as events unfold. With time MSW's learn to anticipate what the midwives need and can position themselves accordingly to support them. Gemma, an MSW from 'Red Ward,' explained that 'You get to learn who will need you next.' As is typical with collective learning, it evolved, as they had experienced the situation together several times before (Bunnis et al., 2012).

### **Reflective Learning**

The previous discussion provides insight into how maternity practitioners learn in unstructured ways during the working day. Learning also occurred naturally when practitioners were given the opportunity for collective reflection and discussion. That way practitioners became more attuned to the ideas, beliefs and diverse perspectives of their colleagues. The research also identified that staff valued connecting and sharing knowledge with others, and that dialogue with more experienced colleagues and peers was an optimal learning practice. Maternity practitioners valued being able to connect and share stories and knowledge. Practitioners also explained that conversations with their peers were valuable in helping them to understand the paradigms from which their colleagues worked. They also saw these opportunities as a way of dealing with some of the ambiguities and tensions that arose in practice.

Reflection enabled midwives in Trust X to learn about the sources of role-related issues. Specifically, both midwives and MSWs use reflection as a way of unpacking the sources of role ambiguity or tension. Professional reflection is an active process whereby practitioners gain understanding about how historical, social and cultural preferences contribute to practice (Schön, 1983; Jasper, 2003).

The second 'disturbance' we have selected from the research reflects ongoing tensions in the maternity units that were heard on numerous occasions. It takes place on a quiet afternoon in the large open plan office area on the delivery ward at 'Blue Ward.' Midwife Doreen is reading one

of the participant information sheets that I, your lead author, had left on top of one of the desk areas. MSW Theresa is drinking coffee and texting on her mobile. Brenda, another midwife, enquires as to the topic of mine and Doreen's discussion. I explain that Doreen and I are talking about my research project. Given your lead author's participation in the following conversation, the attempt to accurately record its content was made immediately after it occurred:

*Disturbance 2: Role Erosion Concerns*

Brenda: 'Ah, this study [our research] it's all about getting more health-care assistants [support workers] on here right . . . ? Well, it's not more healthcare assistants we need: it is more midwives.'

Lead Author: 'No, no I'm not here to try to increase numbers, I'm looking at the role of the MSW and what kind of things they do in different areas of the Trust.'

Brenda: 'Well they want rid of midwives, and I can tell you, they [presume she means MSW] shouldn't be doing certain things, they miss things, don't know how to interpret them properly.'

Doreen: 'No they help complement the midwife, what's the point of the midwife doing the BP [blood pressure] and dipping the urine then seeing the doctor, it's a waste them seeing two professionals. We don't need more midwives we need more MSW's, there is no point midwives spending time on stuff like infant feeding, it's not rocket science if they are trained properly. You can't have them just cleaning, it's a waste of their skills.'

Theresa: 'Yeah exactly, there are times, like yesterday afternoon when you [to Doreen and Brenda] have not got the time to give the full support to women afterwards [after birth] cos it's just so busy. That's something that we could take more responsibility for, we could go in, do the basic things that need doing and [. . .] if we are in there bathing the baby, having a chat, you know 'have you got any kids at home . . . ' you know just general chit chat . . . and you do find if they have a problem or anything they will tell us, they won't always tell a midwife you know.'

Doreen: 'Well yeah there are some midwives who are reluctant to allow maternity support workers to do that sort of thing, but I think nowadays we need to look at what midwives can provide and we can't provide it all, we need to recognise the bits that we can pass over.'

The discussion relates to the MSW role and midwives role erosion concerns. The scenario is an example of what Engeström's (2008, p. 554)

terms 'troubles of talk' caused by the 'multi-voicedness' of participants. This notion is that, within work teams, members have diverse views about themselves and their work. In the 'disturbance' above, the different perspectives of the practitioners are a source of contestation. Despite the different priorities, the discussion favours learning for all the practitioners.

Firstly, the two midwives Doreen and Brenda learn that they have markedly different views about the way in which support workers can be used in practice. These views are also brought to the attention of Theresa, who is given the opportunity to learn some of the reasons why different midwives have varying delegation practices. We have already identified that a source of distress for some MSWs is that they sometimes do not understand why some midwives permit involvement in some duties whereas others do not. All of the practitioners involved in the situation are learning about the values and risks of employing the support worker in practice. Finally, the MSW learns to vocally clarify her role to her midwifery colleagues. That is important given that practitioners in assistant positions often lack confidence defending their role parameters to those in more senior positions (Keeney et al., 2005).

Learning through collective discussion has been identified as a valuable form of learning at work, with such dialogue helping staff to function more effectively within their daily work practice. Research has also identified that dialogue with more experienced colleagues and peers is an optimal learning practice (LittleJohn & Margarayn, 2011). Informal interviews were also carried out with staff in each of the wards. They revealed similar findings. Maternity practitioners explained that conversations with their peers were valuable in helping them to understand the way their colleagues worked and their views on role delineation.

In these interviews, staff were able to reflect upon and discuss very recent practice. The lead author interviewed MSW Julianna one afternoon as she took a ten-minute break from working alongside a midwife. Julianna had been precluded from performing certain tasks such as blood pressure monitoring, conducting urinalysis and providing postnatal support to women. Instead, the midwife had opted for carrying out these tasks herself. The lead author encouraged Julianna to reflect upon the morning and consider what knowledge she may have acquired about practice:

It's a lot of old school, you know. I just think for some it's 'I am the midwife' and they are quite protective of their role, and they say well you can't do that because that's the midwife's role, so yes I guess this is probably why there are issues. [Julianna, MSW, 'Blue Ward']

By being given the opportunity to discuss a specific and very recent aspect of the practice, Julianna spontaneously offered thoughts on what she

felt may underlie the midwives behaviour; ‘old school’ attitudes and role protection. Our research found many other MSWs felt that midwives were hostile towards their role expansion. Arguably, however, if MSWs develop a greater understanding of why midwives hold such attitudes and, therefore, sometimes do not delegate, working relations may improve. Professional reflection is a fundamental aspect in this process. Reflection also enabled midwives in Trust X to learn about the sources of role-related issues:

Well, I guess it’s probably because some [midwives . . . ] feel that they need to do absolutely everything for their woman and it’s probably the way we work in the unit. I trained in a unit a lot bigger than here and we had a lot more health care assistants and the midwives just did midwifery, we didn’t do housekeeping, we didn’t do bed bathing [. . . ] the health assistants did all of that [. . . ] So, yes, when I think about it, there are a few of them who think they should do everything for their woman and they want to do everything for them but obviously it does create tension. [Linda, midwife, ‘Blue Ward’]

Both midwives and MSWs used reflection as a way of unpacking the sources of the tensions and identified the way in which differing ideologies of midwifery shape delegation decisions.

Some authors have argued that reflecting on professional experiences rather than learning from formal teaching is the most important source of professional development and improvement (Jasper, 2003; Schon 1983). The quotes above highlight the value of reflection as a crucial element in improving practice in maternity care. Unfortunately, a key finding in the research was that reflection was a skill that was not easily developed or practised due to time constraints in increasingly busy clinical environments – something we will return to in our recommendations.

### **Emergency Learning**

The third disturbance we have chosen to highlight from our data involves practitioners working around problems in practice:

#### *Disturbance 3: Being Faced with an Emergency*

It’s around 3 pm and the ward seems quite busy. Around 20 minutes earlier Jayne had responded to the buzzer coming from one of the delivery rooms. She had been asked to help with the final stages of a woman who was having a very fast delivery.

The labouring woman is alternating between loud screams and whimpers. The midwife is knelt in front of her monitoring the heartbeat, with one hand on the woman’s stomach and the other on the emerging baby’s head.

The midwife had rung the buzzer about five minutes earlier, to try and attract another midwife but no-one had come.

Midwife says to Jayne: 'I need you to draw up and administer an injection, quickly; do you know how to do that?'

Jayne says: 'Erm, well yeah, but, are you asking me to give it . . . ?' (Hesitates, remains on the spot)

Midwife: 'Yes' (firm tone)

Jayne: 'Pauses, Sytometrine'

Midwife: 'Yeah yeah . . .' (eyes on the woman)

Jayne clearly deliberates (few seconds). Moves over to the bottom of the delivery trolley, goes in a box, pulls out a syringe, and an amp of a drug. Says '1 ml' yeah?

Midwife: 'Yeah the whole lot, the whole amp.'

Jayne draws injection, passes over to midwife who glances to the injection, midwife says 'yep, fine' and points to the woman's left thigh area. Julie injects the woman as midwife watches. At this point, the head and shoulder are out.

After administration, Julie disposes of the needle and walks round to the other side of the patient. Starts stroking her hair and comforting her, 'you are doing great pet, not long now.'

Only a few minutes later the baby is born.

When the lead author talked with Jayne shortly after her involvement in the delivery, she commented that:

I wasn't comfortable doing that you know. When I worked down south we did administer the odd one but I'm talking a long time ago but now, well I don't know. What should I have done, I mean if you are not sure if you should be doing something but the midwife seems to expect you to, can you refuse? I just didn't know how to approach it, I felt awful in there with the poor woman on the bed, she must have wondered why I . . . . [Conversation tails off as support worker bows head] Ohhh . . . afterwards, I worried a lot about it, would I be pulled up for it? I didn't mention it because I came to think well at end of the day she was the one carrying the can.

The situation above arises because staff are faced with an emergency. In medical work, emergencies are acute situations that pose an immediate risk to a person's health. Emergencies often require assistance from other practitioners; usually, there is adequate midwifery staffing to deal with such events. The patient above requires an injection of a drug immediately. The



midwife seeks assistance from another midwife but there is no response to her calls. In interviews, several midwives at the site provided examples of emergency situations where due to a lack of midwifery support they had to ask an MSW to undertake tasks that are not explicitly written in their job descriptions. The above situation is a case in point.

Because an MSW is called to undertake a task she does not know if she is qualified to undertake and is left feeling anxious and distressed about her actions, this disturbance could be termed a 'failure' (Edmonson, 2004). Some of Jayne's uncertainty comes from not knowing if giving the injection is outside her role boundaries. Her hesitation also relates to a lack of knowledge about the consequences. In a later interview, she explains that she wasn't sure it was something 'she should be doing' and was worried she might be later reprimanded for undertaking the action.

The episode was successfully navigated by the two practitioners who collectively learnt to handle a pressurised event so care could continue. Edmonson (2002) terms such practice a 'quick fix,' 'work-around' or first order problem solving and explains that it is particularly common in medical work. First order problem solving removes the immediate obstacle to patient care (the MSW drew up the injection and administered it) but does nothing to change the chances of the situation reoccurring (Edmonson, 2002). In this disturbance, like the previous one we presented, there was no evidence of any collective discussion after the incident. The MSW, whilst notably distressed by the episode, does not share her experience of the event due to fear of being reprimanded. Unfortunately, this fear means that the parties do not learn as much as they might. Other practitioners similarly miss out on the learning opportunities this disturbance might afford. The underlying factors which contributed to the issue are not addressed, thus, the likelihood of a similar situation arising is high.

Collective reflection after the event could have brought several issues to the fore. Firstly, practitioners might learn that when it comes to certain areas of practice, the role boundary of the MSW is fluid. Secondly, practitioners might learn that when faced with extreme uncertainty there are situated practices which can help to ease the discomfort Jayne felt. These might include gentle, yet clear clarification and reassurance by the midwife that she was personally sanctioning the action and therefore responsible. Collective reflection would also ease worries relating to accountability and litigation.

In the above discussion, the activity, theoretical construct of 'disturbances' has been drawn upon in order to capture various tensions and turbulences as they situationally unfold in the delivery of maternity work. This particular construct from CHAT encourages researchers to explore empirical data for noticeable breakdowns in practice. In maternity care, the

notion of disturbances proved especially helpful in making visible the tensions that typically arose at the role boundary between the midwife and the maternity support worker. The three different disturbances explored above whilst taken from different aspects of maternity work, each illustrates the way in which tensions can manifest as a consequence of workload pressures, staffing challenges and role boundary related ambiguities. Using activity theory terminology, the 'division of labour' between midwives and support workers was a significant factor in creating disturbances in daily practice. What was of particular interest to the authors, however, was how navigating the disturbances afforded different types of professional learning for the practitioners involved.

### **Forms and Limits of Professional Learning**

Much of the learning that took place in the maternity wards that we studied was 'local,' closely tied to the situation practitioners were engaged in. Local learning took place through 'observation' of peers in the flow of practice (Myers et al., 2015). In this case, support workers were not learning about best or worst practice, but about the current division of labour and where they could contribute to practice. They also gained valuable knowledge about how they could handle situations in the future. Given the ambiguity and uncertainty about the role of MSWs that we mentioned in opening this paper (Sanders et al., 2016), rules for practice may be presumed to arise locally, situationally and through practice. Therefore, the disturbances were not just disturbances of a presumed order but also the mechanism by means of which order is achieved.

Midwives and support workers were learning in a social context, through their interactions and communications with each other (Vygotsky, 1962). In many of the workplace disturbances identified, it was the social environment, the pressured working conditions and the interactions between different professionals that facilitated the learning. Furthermore, the learning that took place occurred in the flow of the practitioner experience; practitioners were often not consciously aware of what knowledge they were acquiring. Thus, the findings illustrate that learning in maternity practice is not simply a cognitive process but is frequently social and participatory in nature. We may say that support workers and the midwives must in some sense share an experience before new knowledge can emerge. Such experiential learning quickly developed staff confidence and ability to work with colleagues under stressful conditions.

Based on these findings, we argue that if managers in the healthcare sector are to facilitate professional learning, then they must first be willing to actively recognise such valuable learning that takes place in situated and often turbulent practice, and inquire with staff about how to support that.

At the time fieldwork was carried out, practitioners and managers did not acknowledge the learning that took place through the disturbances of which they were part. Increasing awareness of practice-based learning will be important before exploring how to share that learning on a wider organisational level.

A further key finding from the research was the frequency of collective learning. In numerous scenarios, staff were observed developing collective insight and understanding through their interactions. Often the collective learning was not explicit and so not easy to achieve through classroom-based learning methods. Through discussion, practitioners began to learn about the reality of their work and became more attuned to the ideas, beliefs and diverse perspectives of their colleagues. Practitioners also explained that conversations with their peers were valuable in helping them to understand the paradigms based on which their colleagues worked. Interestingly, they also saw these opportunities as a way of dealing with some of the disturbances that arose, including those concerning respective responsibilities. Despite that, there were few opportunities for such joint reflection to take place nor support provided for the practitioners to learn how to better engage with each other in reflective conversation.

Another finding related to 'failures' in practice and learning. In maternity care, when there were breakdowns in performance, staff carried on with daily duties regardless. On one level, whilst this allowed the practice to continue relatively uninterrupted, opportunities for learning via collective discussion were limited. That meant the problems may recur and more significant failures could occur in time (Edmonson, 2002). An implication here is that managers in healthcare could encourage staff to see their workplace as a learning environment where they could openly discuss errors, mistakes and issues of concern, rather than one in which people are blamed for such admissions.

The cross-cutting finding, at this point, is that conversations at work are key to shaping the practice. Therefore, before making recommendations, we can draw on a scholarship to provide additional perspectives on the disturbances we have described in this paper. An ethnographic consideration of the exchanges between midwives and MSWs brings into relief processes of class, gender and professional status. For example, in the third disturbance concerning the administering of injection, we might see a potential discontinuity between a masculinised, directive professional communicative style and a more tentative, subjective and hesitant style. Tannen (1994) shows that social class and professional status may trump gender in shaping workplace conversations. In that exchange, the phatic content of the MSW's speech, which is typically done to establish a connection with someone, finds no echo in the responses of the midwife. The difference between

the participants' styles both reveals and is sharpened by the anxiety, apparently felt by the MSW about whether her action, previously legitimised elsewhere, remained legitimate in this particular context. This highlights how some codes of behaviour are elaborated, while others, including styles of communication, are implicit (Bernstein, 1971). This reminds us that people respond to communication, based on their expectations, which can differ widely, and so reflection on emotions can be useful to overcome misunderstandings. Also, people can change when attention is brought to their patterns of communication and the expectations and feelings of colleagues.

A critical approach to discourse in organisations and healthcare can also bring additional insights to those generated from a more simplistic application of CHAT. It reminds us that MSWs are members of a community, so their actions are mediated by rules and norms, by role-definitions (Benoit et al., 2005) and boundaries, by material instruments and by the evolving object of their activity (helping women to give birth). With an awareness of this discursive aspect to CHAT, we can see how the practitioners in our study were not simply giving voice to some truth of their inner-state, but drawing upon readily available tropes from the prevailing discourse of organisation and professional interaction. That discourse comprises approximate formulations appropriate to each professionally or organisationally situated role. If their talk tends not to produce new configurations, or ways out, it would not be because they lack the necessary ingenuity, but because that discourse constrains and limits their options: it includes what 'goes without saying' (Bourdieu, 1972). Beyond such assumptions lie everything that is unthinkable and unsayable (and all the practices that might have arisen, but did not).

If each practitioner in our study was more of a 'participant observer,' aware of the socially constructed nature of moment-to-moment exchanges and able to act in such a way as to introduce critical reflexivity into the dialogue, sensible of its capacity to produce meaning and transform relations, every such disturbance could become a 'pro-turbance' (our neologism). A proturbance has, enfolded within it, multiple potential future practices and relations amongst which is a best-way-forward. If enough disturbances are recognised as proturbances, they may change every modality described within CHAT: cultural, historical, material, social and discursive. This possibility is the basis of dialogical approaches to organisational learning and change, where shifts in the format and content of conversations then lead to self-organised changes in practices over time (Shaw, 2002; Stacey, 2015; Bush & Marshak, 2016).

The main discursive shift that we recommend, the better to enable professional learning, is to move away from describing 'errors' and 'failures' and to deliberately use words such as 'disturbances,' 'breakdowns' and

'learning opportunities' instead. Such a shift might encourage staff to bring forward episodes of disturbed practice in a spirit of inquiry rather than blame. It would encourage staff to look for the underlying causes of disturbances – rather than personalise an issue – and to discuss ways to prevent the problem recurring. Such activities have been termed 'second-order problem solving' and have been shown to achieve significant benefits for healthcare teams (Tucker, 2004). We recognise that these shifts in framings, and then procedures, are easier said than done.

We recognise that the maternity units we studied are full of people doing their best to bridge the gap between an imaginary organisation of clear roles and calculated procedures and the real organisation of imperfect knowledge and fuzzy role boundaries. That 'real' organisation, experienced every day, is one in which procedures and best practices never catch up with contingencies. As the practitioners we studied continually bridge that gap, they learn and they change. For their individual learning to become collective and institutional learning, there must be a more radical reconfiguration than is implied in the rhetoric of both managerialism and mainstream leadership. Typically, when things go badly wrong, senior managers proclaim 'we take these things very seriously,' and 'we will learn the necessary lessons' – slogans of proceduralism uttered in the voice of an imaginary institution. While that is an understandable response to public criticism, transcending managerialism will be key to better support for professional learning.

The conditions for collective learning include, we believe, orientations towards open, non-hierarchical participation in dialogue; towards an ecological view of the organisation as a living collaboration between interdependent individuals each self-authorised to act in support of dialogue and collaboration (Habermas, 1985). Those conditions also include respect for competence and professional authority tempered by a critically-reflexive habit of questioning, towards a responsive, dynamic view of the aim of institutional action (Engeström, 2008). These conditions are not achieved accidentally, but can be translated into training and can come to permeate policy. How should such professional support be designed and delivered? Our view is that a starting point for any intervention should be solidarity with the staff in maternity wards, underpinned by recognition of and support for their practical daily compassion. We will explore that further now, as it forms the basis for a post-managerialist approach to developing recommendations for interventions.

### **Compassion-Based Approaches to Organisational Development**

One important limitation of management researchers and trainers in examining the healthcare sector might arise from how we typically do not profess the same daily commitment to active compassion as healthcare workers

do. Indeed, many of us exist in institutional cultures that require a dispassionate approach to our subject.

The interpretation of any disturbance should focus on the acceptance of shared humanity and respect for participants – and so should the practice of organisational learning from disturbances. If there is a senior management capability conspicuous by its absence from most lists and operating manuals, it is *humanity*; as, for example, in the kindness of a senior professional acknowledging the desire of an MSW to be useful and joining them to resolve their uncertainties about responsibility and role definition, or the generosity of a more experienced member supporting a less experienced one. Where, in the list of leader virtues reproduced earlier, are humanity or kindness? Managerialism has distracted many of us from the simplest and deepest conditions of collaboration – active practical compassion.

In our study, we have identified compassion as a motivator for people being in a workplace, aspiring to learn and work well, to overcome conflict, and as a necessary dimension of their everyday practice. A review of existing studies in the *Journal of Human Relations* that mention compassion reveals that it has not been considered in this way – as a key focus (Kanov et al. 2016; Lilius et al., 2011). Therefore, we hope our study will encourage more research on the significance of compassion, and its cultivation, at work.

The closest mainstream management studies come to discussing compassion is the field of ‘emotional intelligence’ – a formulaic approach to feelings and empathy. The value of the concept of emotional intelligence is, in our view, diminished by its wide instrumentalisation, as in the *Harvard Business Review* where editors reported on the strong link between empathetic leaders and financial performance (Ovans, 2013), or, worse, turned into an instruction manual for sociopaths: ‘emotions are important because of the open loop nature of the limbic system’ (Boyatzis, et al., 2002). Enabling people to learn from disturbances may need skills of ‘emotional intelligence’ less than acceptance of mutual goodwill and collaborative intent – both abundantly demonstrated by the MSWs in the vignettes above. Therefore, we will base our recommendations on a valuing of compassion.

Healthcare practice is synonymous with compassion (Mills et al., 2015). We may go further and say that health professionals systematise compassion in their practice and that compassion is too easily sentimentalised. Increasingly however, there are concerns that contemporary health care systems are failing to provide safe, compassionate care for their patients. In the UK, there have been a number of high-profile cases detailing inadequate and at times unsafe health care provision. This raises implications for the development of practice standards, or a revision of existing standards that lack notions of compassion in their content. It has been noted that health care providers are under pressure to tighten regulations with some NHS

Trusts going as far as to implement ‘compassion initiatives’ to improve patient outcomes (De Zulueta, 2016). Compassionate healthcare focuses on demonstrations of altruism, kindness, genuine sympathy and empathetic concern for the suffering of patients experiencing health challenges that are often distressing. Evidence suggests that both empathy and kindness as aspects of compassion have a beneficial impact on health outcomes (Frost, 1999). Compassionate health care environments are those where both health care practitioners and patients feel understood, supported, nurtured and cared for emotionally, physically and spiritually (De Zuleta, 2016; Kyle, 2017).

We feel it is timely to discuss a more comprehensive perspective on the relationship between compassion and organisational performance, and one less liable to proceduralism and list-making. How can an institution itself, in its procedural and material affordances, match and support the compassion towards mothers and babies that is the fundamental commitment of midwifery professionals? How can the rhetorical and institutional formulae for management and leadership, like the one quoted in our introduction (Warwick, 2015) and the current NHS model (which includes, without irony, the question ‘Do I carry out genuine acts of kindness for my team?’ (National Health Service, 2013, p. 6), be rewritten so that, rather than anatomising, institutionalising or quantifying complex relations they reflect the complex interplay between compassion and professional competence? We note the contemporary salience of the term ‘emotional wellbeing,’ as in ‘Do I take positive action to make sure other leaders are taking responsibility for the emotional wellbeing of their teams?’ (p. 6). Despite the efforts of its well-intentioned authors, such phrases suggest a drift towards instrumentalism and a tendency to misdirect attention, away from broader social and economic forces, away from local institutional conditions, towards, instead, an omniscient fantasy leader whose ‘self-awareness, self-confidence, self-control, self-knowledge, personal reflection, resilience and determination’ (p. 6) hold everything together. That may be what happens, but the documentary recommendation of it may be seen as an unwarranted incursion by managerialism into the life-world of healthcare workers.

It is questionable to what degree maternity practitioners such as those discussed in this paper can provide compassionate care to their patients if their places of work do not exemplify these same virtues. We imagine that, in a compassionate working environment, both staff and patients would feel understood, supported and nurtured. Furthermore, openness, learning and reflection would arise more naturally in the organisation (to be enhanced, rather than induced, by teachable skills). As discussed earlier in the paper, in such contexts, mistakes, errors and ‘failures’ could be openly and fearlessly discussed.

## Conclusion

Our research found that practitioners in maternal health have abundant resources for moderating workplace conflicts and that moments of disturbance often prompted them to consider roles, boundaries and collaborative practices. Our research shows how learning was occurring through experiential, implicit and evolving processes. Such learning may not be easily parsed and therefore not easily taught. The implication is that any proposed interventions to support workplace performance in maternity should be designed to equip practitioners with the tools for enhanced communication so they better learn together in those experiential, tacit and evolving ways. This means seeing the workplace as a place that can and should be a site of learning that offers opportunities to practice reflective and compassionate conversation. Ultimately, good maternity care needs health institutions and educators to work in solidarity with and to learn from those who express active compassion in their work every day.

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# Understanding Entrepreneurial Intentions of Albanian Business Students Based on the Theory of Planned Behaviour

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This research aims to contribute to the understanding of the effect of entrepreneurship education on entrepreneurial intentions among university business students in Albania. A model interlinking entrepreneurship education and entrepreneurial intention is proposed based on the theory of planned behaviour. Factors related to education that affect the entrepreneurial intentions among business students in Albania are identified and measured. Analysis of the data revealed significant relationships between personal attitudes and entrepreneurial intentions. Subjective norms and perceived control over the entrepreneurial abilities were both not significantly related to entrepreneurial intentions. Discussion of results is presented and future research possibilities are suggested.

*Keywords:* entrepreneurship education, Theory of Planned Behaviour, entrepreneurial intention, perceived desirability, perceived entrepreneurial control, subjective norms

## Introduction

For almost four decades, Albania has faced one of the most extreme communist dictatorships in Europe, characterised by a total isolation (Xheneti & Bartlett, 2012). As a result, the system of higher education in Albania was obsolete in methodology as well as in the information provided. In the post-communist era, Albanian higher education system underwent a series of reforms, including radical institutional changes, aiming at adapting to the new democratic system. One of these reforms was the liberalisation of the Higher Education Institutions which resulted in a rapid increase in both public and non-public Higher Education Institutions. In the same period, comparable growth has emerged in the field of entrepreneurship education. But the higher education sector – including business education – is facing a great number of problems, and the system has to change in a variety of ways, including shifting of the focus from quantity to quality

and creating the opportunity for a quality education. In addition, the revival of entrepreneurship in the country definitely will contribute to job creation, flexibility and competitiveness, innovativeness and job satisfaction (Shaqiri, 2015). A study of return migrants to Albania by (Piracha & Vadean, 2010) shows that formal education significantly predicted their entrepreneurship aspirations.

Nevertheless, little research has been conducted on the effects and effectiveness of entrepreneurship education programmes and the question of whether entrepreneurship education can influence entrepreneurial intention is still relatively unexplored. For many countries in South East Europe (SEE), entrepreneurship is linked mainly to management training instead of being considered as a process of acquiring attitudes (Xheneti, 2007). As an economy in transition, Albania needs to create a sustained basis of growth. Self-employment backed by entrepreneurial education can be part of the solution or an alternative way to joblessness. According to the The Quality Assurance Agency for Higher Education (2012), the ultimate goal of entrepreneurship education is to develop entrepreneurial effectiveness through multidisciplinary approaches and mixed pedagogies in order to achieve a balance of skills and knowledge related to the three contributory aspects: enterprise awareness, entrepreneurial mind-set, and entrepreneurial capability. As Xheneti (2007) suggests, the benefits of entrepreneurship education are not limited to more start-ups, innovative ventures and the creation of new jobs.

Entrepreneurship education can stimulate personal attributes and improve creativity, initiative, and can also promote innovation, self-confidence and the full potential of all individuals (Qorraj, 2017; Zepeda, 2013). Entrepreneurship education is the first and arguably the most important step for embedding an innovative culture in Europe (Wilson, 2008), and since the future of Albania is to be integrated into the EU, its economic growth competitiveness and innovation depend on being able to produce future leaders with the skills and attitudes to be entrepreneurs in their professional lives. Thus, one of the roles of the entrepreneurship education is to affect entrepreneurial intentions, affecting the attitudes and perceptions such as perceived desirability of self-employment and perceived entrepreneurial self-efficacy (Iqbal et al., 2012). This research paper attempts to study the effects of entrepreneurship education on determinant factors, such as attitudes, norms, and perceived control over the behaviour. In turn these determinant factors will affect the entrepreneurial intentions.

### **Background and Hypotheses**

It is widely held that today's students become tomorrow's entrepreneurs and entrepreneurship education is often integrated into traditional curric-

ula to ensure that this path is clear. In the past, researchers have examined how education in entrepreneurship could transform learners into entrepreneurial practitioners (Basu & Virick, 2008; Chen et al., 2015; Franke & Lüthje, 2004). Entrepreneurial intention has now become a preferred outcome in the business education assessments. Entrepreneurial intention is frequently employed as a theoretical framework in the literature (Fayolle & Liñán, 2014).

This research design interlinks entrepreneurial intentions of business students with the Theory of Planned Behaviour (TPB) model developed by Fishbein and Ajzen (1975) and Ajzen (1991). The TPB has been used by several researchers as a framework to study and explore entrepreneurial intentions (Fayolle & Gailly, 2004; Linan & Chen, 2009; Karali, 2013; Kolvereid & Isaksen, 2006; Kolvereid, 1996; Krueger et al., 2000). According to Ajzen (1991), attitudes toward the behaviour, social norms with respect to the behaviour, and perceived behavioural control are usually found to predict behavioural intentions. This research follows Basu & Virick (2008) in modelling entrepreneurial intentions after the theory of planned behaviour but explores the validity of the model within the nuances of the Albanian business education context.

In summary, the (TPB) postulates the following three predictors of intention, as cited in Karali, (2013, p.9):

- *Attitude toward the behaviour.* This is the degree to which a person has a favourable or unfavourable evaluation or appraisal of the behaviour in question.
- *Subjective norms.* These are the perceived social pressures to perform or not the behaviour.
- *Perceived behavioural control.* It is the perceived ease or difficulty of performing the behaviour. This predictor is assumed to reflect the perceived ability to perform certain tasks as well as anticipated impediments and obstacles.

The theory predicts that the greater the favourable attitude and subjective norm (social support) with respect to the behaviour, combined with a strong perceived behavioural control (ability), the greater the intention will be to perform the particular behaviour (Karimi et al., 2012).

The literature reviewed points to a further need for exploration of entrepreneurship education and its impact on entrepreneurial intentions. The coming points will detail the backgrounds, methodology and the findings of this study in detail.

In the light of the discussion above, this research tests three hypotheses. Personal attitudes are related to the expected value of starting a business such as financial rewards, personal satisfaction and independence

(Krueger et al., 2000). As a result, students with a high expected value will show a strong tendency to start a business. In this case, it is expected that university educators' aim is to help students discover and develop personal attributes for successful enterprise, develop an awareness of these, and find opportunities to enhance them. From the other part, students should be able to demonstrate ability of self-confidence, perseverance, action orientation, innovation and creativity. In simple terms, those with favourable personal attitudes towards something will more likely intend to perform action that lead to behavior aimed at achieving it (Fayolle & Gailly, 2015).

*H1 There is a positive and significant relationship between personal attitude towards entrepreneurship and entrepreneurial Intentions among Albanian business students.*

This is an important determinant for university students since they can be influenced by their social environment. Support and opinions from friends are likely to encourage or discourage a potential entrepreneurial behaviour (Zhang et al., 2015). Culture is a hidden ingredient in determining the entrepreneurial direction of a society – certain cultures have in them memes that nurture or hamper entrepreneurial behaviour of people and institutions finding existence in them. Social norms of the group with which a person aligns could determine that person's entrepreneurial attitude, note Qureshi et al. (2016). Entrepreneurial identity aspiration as a personal attitude is also observed to be another critical factor influencing entrepreneurial intentions (Pfeifer et al., 2016).

*H2 There is a positive and significant relationship between social norms and entrepreneurial intentions among Albanian business students.*

University students who believe they have acquired the skills to start a business are likely to become entrepreneurs (Zhang et al., 2015). Those abilities are supposed to be developed by university educators, whose aim is to help students develop core skills for enterprise and provide opportunities for these to be practiced within a range of situations to gain enhanced confidence and self-belief. From the other part, students should be able to demonstrate ability in the area of creativity and innovation, persuasion and negotiation, approach to management, decision making, financial and business literacy (The Quality Assurance Agency for Higher Education, 2012, p. 16–17). Perceived self-control and action-related doubt are found to be influencing individuals' choice to become entrepreneurs (Van Gelderen et al., 2015). Those with greater internal locus of control might be more willing to engage in planned behaviour that results in entrepreneurial actions and outcomes (Hsiao et al., 2016).



- H3 *There is a positive and significant relationship between perceived behavioural control and entrepreneurial intentions among Albanian business students.*

### Methodology

This research seeks to describe trends in a population of individuals, in this case the Albanian business students. The design for this research is planned to be quantitative correlational. The design is suitable for the research as it seeks to describe students' perception of their entrepreneurial intentions and how intentions may be affected by entrepreneurship education programmes. The main dependent variable in this study is the entrepreneurial intention, which is considered the most appropriate indicator for measuring the direct impact of an entrepreneurship education programme.

The primary theoretical assumption guiding this inquiry is that entrepreneurship education has a positive impact on entrepreneurial intentions. This study assumes that the more favourable attitudes toward behaviour, subjective norm, and perceived behavioural control toward the behaviour are, the stronger the intention to perform the behaviour will be (Ajzen, 1991). It focuses on investigating whether young graduates have the necessary skills (as self-perception) that are required to become part of the entrepreneurship world. An important part of the research is the investigation of the role of higher education institutions on how they influence the entrepreneurial capabilities, self-reliance and self-independence in motivating the young students to initiate their own, new businesses. The study will identify the contribution of the independent variables in creating entrepreneurial intentions and how they relate to the dependent variable – entrepreneurial intentions. The study will be focused on Albanian business students. This research method aims to provide a statistical investigation of the relationship between the independent variable and the dependent variables. The research design will incorporate the collection of data from respondents using a questionnaire and the analysis of that data using statistical methods of analysis.

### Data and the Basic Structural Equation Analysis

This form of quantitative research seeks to describe trends in a population of individuals (Albanian business students) and in this case, a survey is a good procedure to use. Using the software facilities provided, such as the R-Studio, the completed questionnaire responses are processed for the initial statistical analyses. A questionnaire is administered to a group of students (the sample) to identify trends in behaviours, attitudes and skills. The sample population consists of university students in Albania at their un-

dergraduate final term level studying in the business administration department. There are 201 responses, representing three public universities and four private universities. The total sample is divided in two subgroups. In the first one, students who took the entrepreneurship major were included, and was considered the Target Group. In the second subgroup, students who had not been exposed to entrepreneurship studies were included, and was considered the as the Control Group. Samples of students are very common in the entrepreneurship literature (Linan & Chen, 2009; Kolvereid, 1996; Krueger et al., 2000) and as a quantitative study, a minimum of 30 individuals in the sample size ensured a normal distribution for parametric analysis, such as correlation (Triola, 2009).

Selection of this sample has been made for two reasons. First, final year university students are at a stage when they are most likely making career related decisions. Second, the students are about to face their professional career choice, so they may answer the Entrepreneurship Intention Questionnaire more consciously.

The model used to evaluate the entrepreneurial intentions can be written as follows:

Entrepreneurial Intention =  $f(\text{Perceived Desirability, Subjective Norms, Perceived Entrepreneurial Abilities/Skills})$

$$EI = \alpha + \beta_1 PD + \beta_2 SN + \beta_3 PEA + \varepsilon$$

### **Reliability and Validity**

The instrument used for this study, titled entrepreneurial intention questionnaire (EIQ), has been developed and tested for reliability and validity by Linan and Chen (2009) and used by other researchers (Iqbal et al., 2012; Karali, 2013; Zhang et al., 2015). The study sought to investigate the relationship between students' entrepreneurial intentions and its antecedents (key attitudes that predict intention) that are composed of students' subjective norms, personal attitudes towards entrepreneurial behaviour, and perceived behavioural control, which in turn influences the entrepreneurial intention. The first step was validity analysis. There are several validation procedures and methods (Chandler & Lyon, 2001; Messick, 1988). The instrument was checked for structural and content validities and the items were both relevant and representative of the construct being measured. Although the reliability of the instrument was tested by its developer, the construct used for this study was checked again for inter-item consistency. The Cronbach's alpha shows a range between 0.64 and 0.77. The alpha value between 0.2 and 0.4 is considered reliable (Briggs & Cheek, 1986) and a value of 0.70 is considered satisfactory for most studies (Nunnally, 1978).

**Table 1** Descriptive Statistics

Construct	Mean	SD	Level
Perceived Desirability	5.15	1.00	Moderate to High
Subjective Norms	4.63	1.07	Moderate
Perceived Entrepreneurial Abilities/Skills	5.47	0.93	Moderate to High

**Table 2** t-Test Results for Students' Perceived Desirability, Subjective Norms and Perceived Entrepreneurial Abilities/Skills

Construct	Type of University	Mean	t-test	P-value
Perceived Desirability	Public	5.01	-2.994	0.003154
	Private	5.41		
Subjective Norms	Public	4.47	-2.987	0.003216
	Private	4.91		
Perceived Entrepreneurial Abilities/Skills	Public	5.44	-0.595	0.552800
	Private	5.52		

**Data Analysis**

First, in Table 1 are presented the means of the three antecedents of the entrepreneurial intention ranging from moderate to high levels.

Although the Welch Two Sample t-test have shown (Table 2) an insignificant difference between the public and private university means for the Entrepreneurial Intentions, the other independent variables have shown a significant difference, except for the Perceived Entrepreneurial Abilities.

The Pearson's product-moment correlation (Table 3) has shown a significant correlation between each of the independent variables (three antecedents) and the dependent variable (entrepreneurial intention). The correlation between perceived desirability and entrepreneurial intention is 0.55 ( $p$ -value  $2.20e^{-16}$ ), subjective norms and entrepreneurial intention 0.39 ( $p$ -value  $2.16e^{-8}$ ), and the perceived entrepreneurial abilities/skills and entrepreneurial intention is 0.28 ( $p$ -value 0.0001172). The correlation results between the intention antecedents and the intention proves also the inter-item consistency of the construct.

The regression model built in this research takes into consideration the base model according to the theory of planned behaviour (Ajzen, 1991), which predicts that attitude, social norm, and controlled behaviour are as-

**Table 3** Pearson's Product-Moment Correlation

Construct	Correlation	T	DF	Pr(> t )
Perceived Desirability	0.55	9.0235	189	$2.20e^{-16}$
Subjective Norms	0.39	5.847	189	$2.16e^{-8}$
Perceived Entrepreneurial Abilities/Skills	0.28	3.9341	189	0.00012

**Table 4** Regression Analysis

Construct	Estimate	Std. error	T-value	Pr(> t )	Mult. R <sup>2</sup>	Adj. R <sup>2</sup>
Intercept	1.12349	0.58548	1.919	0.0565	0.3207	0.3098
Perceived Desirability	0.60244	0.10262	5.870	1.95e <sup>-08</sup>		
Subjective Norms	0.16068	0.09556	1.681	0.0943		
Perceived Entrepren. Abilities/Skills	0.14976	0.09298	1.611	0.1089		

sociated with entrepreneurial intention. The results of the linear regression are presented in Table 4. Among the three intention antecedents, the effect of perceived desirability is significant, and the coefficient is 0.6. The coefficients of subjective norms and controlled perceived entrepreneurial abilities are both not significant.

In conclusion, this research paper has found support that perceived desirability is positively associated with entrepreneurial intention, however, subjective norms and perceived entrepreneurial abilities have shown a weak association with the intention. Thus, only Hypothesis 1 has received support.

## Discussion

First, the study compared the means of intention determinants between private universities' students and their counterparts at public universities. The results have shown that there is a significant difference between the scores for the perceived desirability and subjective norms between students in both types of universities. Students from private universities had significant higher perceived desirability and subjective norms to become entrepreneurs. This indicates that the environment in private universities was more effective in constructing a sense of social support and personal experience among students.

Second, the study provided important results on the regression model. The positive relation between the perceived desirability and intention could be explained by the personal entrepreneurial experience among university students, so university students have an easy time to assess the expected value of starting a business. The case is different for subjective norms and perceived entrepreneurial abilities/skills, where university students can not accurately assess these two constructs.

The regression model indicates a mean variation in the subjective norms and perceived entrepreneurial abilities/skills that correlates little with the variation of intention. Students are unsure about the support of their individual social environment to start a business, and the same is for their inner ability/skills to start and run a business. Regarding the effect of perceived desirability on intention, the study has found that it has the highest impact.

This indicates the perceived desirability is the main drive of entrepreneurial intention among university business students.

The findings suggest that exposure to entrepreneurship education has not a significant positive effect on students' subjective norms and perceived entrepreneurial abilities/skills that would lead to strong entrepreneurial intentions. Entrepreneurship education should play a stronger role in the development of entrepreneurial intentions. Therefore, entrepreneurship educators in public and private universities should help students develop core behaviours for enterprise through learning activities that enable them to practice, exhibit and develop confidence in key areas.

From the other part, students should be able to demonstrate ability of opportunity recognition, problem solving, managing autonomously, networking and communication (The Quality Assurance Agency for Higher Education, 2012).

In addition, students should experience various tasks of an entrepreneur since they play a critical role in enhancing students' self-efficacy and intention (Fayolle & Gailly, 2008; Zhao et al., 2005; Henry et al., 2003). These are all important steps in support of the argumentation that attitudes are open to change. In the context of two schools of thoughts that prevail in the context of entrepreneurship (the nascent entrepreneurship and planned behaviour entrepreneurship), this study supports the applicability of the theory of planned behaviour, in learning, intention, and behaviour.

## Conclusion

Because of its communist heritage, the model of education in Albania was generally uniform in the sense of methods of teaching and studying (Welter & Smallbone, 2011). The educational system was meant to prepare young people for the entry into the centrally planned economy and thus producing uniform models of behaviour (Xheneti & Smallbone, 2008). For long, unfair competition, inadequate banking intermediaries, and lopsided taxation policies too demotivated entrepreneurs (Bitzenis & Nito, 2005). Corruption continues to be a major impediment to the nation's progress. In such climates, an entrepreneur's ability to navigate corruption may become a greater predictor of successful entrepreneurship than the presence of a corruption free business environment. Such abilities are embedded in the social capital and tapping them for opportunity exploitation might determine who gets to win.

Generally speaking, it is now recognised that in Albania business education should promote entrepreneurial attitudes and behaviours, and moreover is important to stimulate the entrepreneurial mind-set and encourage innovative business and new start-ups ideas (Kasimati & Koxhaj, 2011). As stated by OECD (2009) there is no single approach to the evaluation of ed-

education for entrepreneurship programmes, but a combination of qualitative and quantitative approaches may be used. Based on the ideas presented above, the innovative aspects of this proposed research is to evaluate the education for entrepreneurship based on the three elements suggested by the The Quality Assurance Agency for Higher Education and that educators should aim to develop: enterprising *behaviours, attitudes and skills*.

The results of this study may have implications for entrepreneurship educators, higher educational institutions, private sector and policy makers in Albania. In this context, the academicians and university authorities should rethink about what is to be done in order to better teach and prepare younger generations for the forthcoming challenges. As observed before, analysis of the data revealed significant relationships between personal attitudes and entrepreneurial intentions. Subjective norms and perceived control over the entrepreneurial abilities were both not significantly related to entrepreneurial intentions.

Something that does not go well with the mainstream findings is the weak correlation between perceived control and entrepreneurial intentions (Rapp-Ricciardi et al., 2018). It is generally held that greater sense of control over one's destiny (internal locus) would lead to greater entrepreneurial drive (George, 2018). Why is this not the case among the Albanian students? We could hypothesise that this is due to the way locus of control is constructed in different cultures. If it is constructed as a dependent variable, cultures would try to preserve the status quo. If Albanian culture holds that they have a certain amount of control over their futures as a result of the ways they always do things, they will not change their ways. However, this needs to be tested empirically.

The research also provides valuable feedback to Albanian universities, in order to offer more well-structured entrepreneurship educational programmes to students. The results of this study will facilitate efforts for further research to explore ways and means to promote and encourage entrepreneurs generally and students particularly. Also, based on the results of this research, Albanian policy makers should start to better understand the degree up to which entrepreneurship education is effective in achieving its goals and allocating the resources necessary for it. From its part, the Albanian government should see public universities as hubs that can develop future entrepreneurs, and to concentrate on the results of education rather than the number of the educated.

One important area that we did not address is the additional nuances associated with international entrepreneurship (George et al., 2020). With increasing levels of EU integration and globalisation of the region, a whole new set of drivers related to entrepreneurship need to be emerged. Factors that make cross-border entrepreneurs successful too need to be embedded

into the business curriculum (Tukamushaba et al., 2011). This is another potential avenue for future research.

### Notes

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## **Appendix**

### *The Questionnaire*

Indicate your level of agreement with the following statements from 1 (strongly agree) to 5 (strongly disagree):

- Being an entrepreneur implies more advantages than disadvantages to me.
- A career as an entrepreneur is very attractive to me.
- If I had the opportunity and resources, I would love to start a business.
- Being an entrepreneur would give me great satisfaction
- Amongst various options, I would rather be anything but an entrepreneur.

If you decided to create a firm, people in your close environment would approve of that decision? Indicate your level of agreement with the following statements from 1 (strongly agree) to 5 (strongly disagree):

- Closest family.
- Closest friends.
- Other important people to you (colleagues).

Indicate your level of agreement with the following statements from 1 (strongly agree) to 5 (strongly disagree):

- For me, developing a business idea would be easy.
- The number of events outside my control which could prevent me from starting a new business are very few.
- I believe I can successfully conduct market analysis related to starting a new business
- I believe I can identify potential new venture funding.
- I believe I can identify and build a management team to develop a business.
- I believe I can develop business relationships with key people to assist in a business opportunity.
- I believe I can tolerate unexpected changes in business conditions.
- I believe I can work productively under continuous stress and pressure from work.
- If I tried to start a firm, I would have a high probability of succeeding.

Indicate your level of agreement with the following statements from 1 (strongly agree) to 5 (strongly disagree):

- I'm ready to do anything to be an entrepreneur.
- My professional goal is becoming an entrepreneur.
- I will make every effort to start and run my own firm.
- I'm determined to create a firm in the future.
- I have very seriously thought in starting a firm.
- I'm going to start my own business within one year of graduation.
- I'm going to start my own business someday in the future.

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# Supplies Inventory Management in a Corporation Context: A Case Study

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Inventories and inventory management are integral in supply chain and logistics activities. This study analyses supplies inventory management in a corporation and the unique challenges in this context. The study is qualitative, and a case study of an organisation's inventory management practices is conducted. The findings highlight the importance of reliable inventory data, documented inventory management practices and unified inventory management organisation. They also illustrate the issues and development needs in supplies inventory management in a corporation. Despite the single case study generalisability limitations, managers can utilise the findings as a reference for inventory management development projects in corporations.

*Keywords:* inventory, inventory management, corporation, supply chain management (SCM), logistics

## Introduction

Inventories are frequently seen as cost centres that act as buffers in supply chains and temporary places for storing items (Richards, 2018). Inventories influence the business, as logistics costs are approximated to be several percentages of the revenue of construction and retail firms, and inventory costs form roughly 50 % of overall logistics costs (Solakivi et al., 2018). In other words, inventories have a direct effect on the supply chain and logistics efficiency (Lummus & Vokurka, 1999; Silver et al., 1998).

Richards (2018) describes different inventory types, such as supply, raw materials, work-in-progress (WIP), maintenance and spare parts inventories. Although inventories are costly for companies, they exist for good reasons. These are often related to, for example, achieving economies of scale, balancing supply and demand and controlling uncertainty in the markets (Krajewski et al., 2019).

When considering the basis of inventory management, questions including 'What items should be stocked?', 'Where should the items be stocked?' and 'How much of and when should the items be ordered?' arise (Muck-

stadt & Sapra, 2010). In addition, three elements are identified from the literature that form the basis for efficient inventory management and its development: supply chain and materials management for achieving overall efficiency (Lambert et al., 1998; Silver et al., 1998), information systems for allowing real-time data and knowledge-based management (Faber et al., 2002; Weske, 2012) and the organisation of management and personnel for controlling and developing the inventory process (Lee & Dale, 1998; Yingling, 1997).

With these factors in mind, this study aims to analyse supplies inventory management challenges in a corporation context. In particular, a diverse corporation environment provides a large variety of needs that should be met, and naturally, more challenges can emerge as a result of this more complex environment, compared to a single inventory and company context. This study focuses only on supplies inventories in the case organisation. The above-mentioned objectives of the study can be condensed into the following research questions (RQs):

RQ1 *What is the current state of and development needs for supplies inventory management in the case organisation?*

RQ2 *How does the corporation context affect supplies inventory management?*

The research questions are addressed through literature findings on efficient inventory management and empirical analysis. The current state analysis is formed by conducting semi-structured face-to-face interviews, collecting inventory data from different information systems and documents and observing the inventory process in the case company's facilities. The paper is structured as follows: First, the elements of efficient inventory management are described. Then, the research method is explained. The case description and analysis are observed in the results section. Finally, the results of the paper are discussed from theoretical and managerial perspectives.

## Literature Review

### **Supply Chain and Materials Management**

Supply Chain Management (SCM) can be considered as the integration of business activities from suppliers to end users (Prajogo et al., 2016). Van Weele (2010) highlights that the initial objective of SCM is to satisfy or exceed the needs of the end user. Materials management is, therefore, according to Arnold et al. (2008), a coordination procedure for planning and controlling material flows. Lambert et al. (1998) describe the basic elements of materials management as follows: anticipating material requirements, sourcing and obtaining materials, introducing materials into the or-

ganisation and monitoring the status of materials as a current asset. All these activities should be linked to organisational goals and strategy (Lambert et al., 1998).

SCM and materials management are strongly related to each other. Typically, two basic functions can be found in the supply chain: receiving and shipping materials. In addition, managing information and capital flows is essential in supply chain management (Hugos, 2018). It is important to understand that problems in managing supply chains and materials are visible in the form of wrong inventory levels and overall inefficiency (Lambert et al., 1998; Lee, 2002), and as mentioned, inventories themselves are costly (Krajewski et al., 2019). Hence, these activities should be optimised.

The need for stock can be evaluated by conducting an ABC analysis, which highlights the fact that different items require different control strategies (Chu et al., 2008). Braglia et al. (2004) present that, for example, items with high demand and value should be stored or acquired, utilising the just-in-time (JIT) method in order to minimise inventory costs. By exploiting the JIT philosophy, the need for own stocks is basically zero as the items are supplied at the right time to meet targets, but due to the risk of delivery failure, own safety stocks are compulsory in certain situations (Krajewski et al., 2019). Users demands, the reliability of the supply chain and the relationship between the firm and the supplier all have an effect on which control strategy is implemented and on the amount of stock required. These strategies include, for example, storage in the company's own facilities or letting the supplier take care of inventory activities (Wallin et al., 2006).

Spare parts for maintenance control strategies differ from others because of their different nature (Kennedy et al., 2002; Puurunen et al., 2014). Criticality, value, part speciality and demand should all be taken into account when choosing the right control strategy (Huiskonen, 2001). Huiskonen (2001) observes that the relationship between suppliers and other actors in the field should be deepened by utilising, for example, common inventory pools for spare parts with high value and criticality but often very low demand. Good examples of cooperation with suppliers are consignment stock and vendor-managed inventory (VMI), where, in both cases, the supplier participates in a company storage and inventory management (Beheshti et al., 2020; Lakra & Bedi, 2014).

Naturally, the operative work conducted by the inventory personnel is very important in order to keep the inventory in good shape and well organised. Van den Berg and Zijm (1999) describe the inventory process as follows: receiving, stocking, order picking and shipping. This operative work should include, for example, regular manual inventory verification where the items are manually counted in order to correct inventory records (Kang & Gershwin, 2005).

### **Information Systems**

As competition increases, the importance of information systems in controlling and improving processes grows (Lee, 2002; Weske, 2012). Systems that allow the controlling of inventory levels, such as warehouse management systems (WMSs) and enterprise resource planning (ERP), make it possible to optimise inventory levels and material flow (Faber et al., 2002). In addition, the use of information systems has increased the overall efficiency of supply chains in a remarkable way (Cachon & Fisher, 2000).

Whereas a WMS is a system for controlling an inventory process (Faber et al., 2002), ERP allows an even broader approach as it offers a large variety of new ways to do business and to increase integration inside the company (Ali & Miller, 2017; Krajewski et al., 2019). Furthermore, Umble et al. (2003) state that the benefits of using ERP are not only limited to industrial companies as it can be utilised in any firm that wants to optimise its operations.

The automation of ordering through ERP decreases inventory levels and the amount of orders made (Krajewski et al., 2019). This kind of activity is possible by setting lead times, safety stock, reorder points (ROPs), the economic order quantity (EOQ) and the maximum inventory level in terms of the system variables (Wen-Yong et al., 2011). The data provided by information systems help management in decision-making and allow knowledge-based management instead of the making of intuitive decisions (Jääskeläinen & Luukkanen, 2017; Strijbosch et al., 2000). To aid decision-making, key performance indicators (KPIs) are created to measure the variables that are the most important for the success of the company (Parmenter, 2007). KPIs are essential when the organisation wants to recognise the factors that are vital for developing inventory management practices (Johnson & McGinnis, 2010), and it can be generalised in terms of the fact that information systems and the data provided have a lot of weight when developing business processes in an organisation (Zairi, 1997). It should be remembered that the sub-optimisation of different processes should be avoided (Yingling, 1997). This supports the acquisition and utilisation of common ERP by the organisation in order to achieve transparency and maximum business efficiency.

### **Organisation of Management and Personnel:**

#### **Business Process Management**

Business process management (BPM) is a systematic approach that enables the analysis, development and control of processes (Hung, 2006; Lee & Dale, 1998). In essence, BPM is a tool for fulfilling cultural change in an organisation related to the considered process (Zairi, 1997). Dumas et al. (2013) observe that BPM focuses on controlling and developing value-



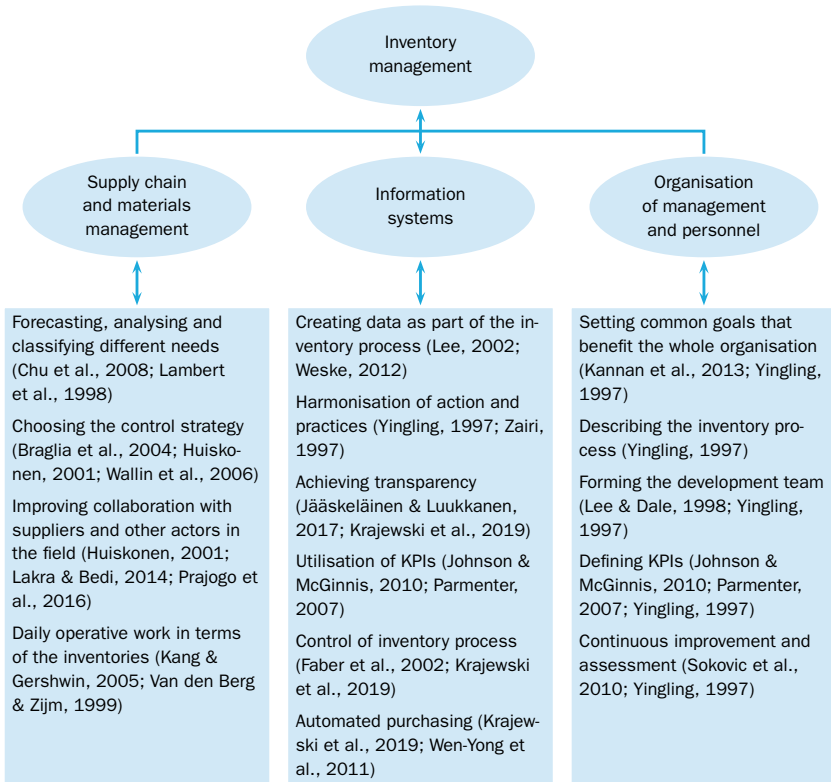
adding activities as a whole, instead of concentrating on single processes.

To make BPM possible, Yingling (1997) presents the necessary organisation and people in terms of three different levels: at the heart of the management system is the management team, the second level consists of department teams within the organisation and the outer level is formed by the key business process teams. BPM itself is implemented in five steps: identify key processes and related goals, define key cross-functional business processes, form teams and develop a charter, develop measures and continuously manage the process (Yingling, 1997). A systematic approach is vital for success (Lee & Dale, 1998; Yingling, 1997; Zairi, 1997). In the last step, the PDCA method (also known as the Deming circle), discussed by Sokovic et al. (2010), is suitable as the development work requires continuous monitoring and examination by conducting regular meetings within the development team (Yingling, 1997).

The key business process team's job is to supervise and manage the inventory process as they are responsible for ensuring that the process is managed and performed correctly, and as mentioned, sub-optimisation should be avoided (Yingling, 1997). It should be remembered that common policies and goals related to overall business and inventory management result in decreased overall costs and bigger profits and, therefore, support the business overall (Kannan et al., 2013). All the elements that form the basis for efficient inventory management according to the literature review are illustrated in Figure 1.

## Research Method

This study is qualitative in nature, and a case study strategy (Eisenhardt, 1989) was employed. The study began by analysing the elements of efficient inventory management, i.e. supply chain and materials management, information systems and the organisation of management and personnel. After that, a current state analysis of the case organisation's inventory management was conducted. The selected case organisation is a Finnish corporation in the energy sector. A current state analysis was created by carrying out semi-structured interviews with twenty people (from top management to the operative level) in the corporation, one group interview, collecting and analysing inventory data from information systems and documents and observing inventory management practices in the corporation's everyday work. The interview questions were divided into six categories according to the interviewee's position: 1. top management, 2. energy producing and maintenance, 3. finance, 4. inventory users, 5. inventory personnel and 6. IT administration. The questions focused on fundamental inventory issues, such as current inventory practices in the company, problems and challenges and different needs based on the interviewee's position. The data analysis fol-



**Figure 1** The Elements of Efficient Inventory Management Based on the Literature Review

lowed guidelines by Eisenhardt (1989). The analysis was conducted using a qualitative approach, i.e. reading the interviews several times, each time going deeper into the data to find connections, patterns, and comparisons. Current state analysis is unique to the corporation level, and therefore, it was deemed to be very beneficial for the case organisation. In the last part of the study, the effects of the corporation context related to inventory management were analysed and validated, and the related implications were discussed and concluded.

## Results

### Case Description

The case organisation is a Finnish energy company that was established back in the 1880s and is located in Northern Finland. The company’s revenue was approximately 300 million euros, the profit was roughly 30 million euros, and it employed, on average, 400 people in 2018. The company provides energy services and clean energy. Its operations cover the entire

value chain of the energy industry from the production of raw materials to the generation, sale and distribution of energy. In addition, the company provides smart energy services, network management, subcontracting and maintenance services.

The case organisation consists of a parent company and five subsidiaries. The parent company can be divided into two different business areas: energy production and heat services. The main goal of this six-month research project was to create an understanding of the current state of the corporation's supplies inventory management. This kind of research has not been conducted before at the corporation level concerning supplies inventories. The sub-goals were to create and distribute information regarding efficient inventory management practices within the corporation and to find common development needs.

Before the research, the understanding and transparency of different supplies inventory management activities and practices within the corporation were limited. Each subsidiary had its own supplies inventories in different geographical locations. The inventories included a large variety of different items, for example, cables and transformers. This diversity resulted in diffused inventory management practices. In this study, the current state analysis is conducted during the empirical research in order to create a corporation-level inventory management framework.

### **Current State Analysis**

This section presents the findings related to RQ1: What is the current state of and development needs for supplies inventory management in the case organisation? The current state analysis started in May 2019. The researcher observed the inventory management practices within the corporation and investigated data from the available information systems and documents. The first step involved forming the basis of the current state analysis including, for example, the locations of supplies inventories and the types of items that were stored in them. After that, interviews were conducted within the organisation. The interviewees were mostly in management positions because of the insufficient organisation of operative inventory management and the limited number of people allocated to operative work.

Based on the current state analysis, it was obvious that there were shortages and challenges in every element of the theoretical framework presented in Figure 1. The main challenge was the inexistence of real-time and reliable inventory data. Because of the lack of accurate data and the inexistence of KPIs, visibility at the operative level was poor, and as a result, knowledge-based decision-making was difficult. In some inventories, storage workers controlled the daily material flow. In general, the inventory

management organisation and the people responsible, whose main focus was on inventories, were fragmented and defective. In most cases, inventory management and the control of material flow took place as a side task. Daily inventory management, which focused mainly on controlling inventories, did not extend to the biggest part of the corporation's inventories. Also, the supplies inventories were not centralised because each company had their own storage in different locations. Thus, it was difficult to control the inventories.

The lack of process documentation for controlling the materials resulted in subjective decision-making in the inventories. Because of this, the work conducted by the personnel and inventory users was, in most cases, based on each person's own views and experience. The interviewees admitted that there were challenges and uncertainty in the general rules and procedures concerning supplies inventories. The roles of inventory management were unclear, and the basic practices for diffused supplies inventories were incomplete.

The supplies inventories faced problems, such as the shortage of free space and the high number of non-marketable or unknown items. In the worst-case scenario, broken items were mixed with and stored in between intact articles because the rules and positions regarding storage were not generally documented and visible. As a result, it was possible to retrieve broken items in urgent situations. This happened frequently in inventories where storage workers were absent and where overall disorder was high. The lack of free space caused issues when orders were made at the wrong time and when items arrived at the inventory too early. In cases like this, an understanding of the supply chain and ordering at the right time are important in order to maintain optimal inventory levels.

It was notable that the current problems and challenges led to indirect costs and overall inefficiency in the corporation's everyday work, which also resulted in, for example, extra time taken in finding items in the inventories. The current inventory management did not support the corporation's business and was not in line with its strategy. The challenges and related implications can be seen jointly in Table 1.

### ***Inventory Management Challenges in a Corporation Context***

This section presents the findings related to RQ2. How does the corporation context affect supplies inventory management? The current state analysis indicated that there were many basic-level challenges concerning the corporation's supplies inventories. The first challenge identified from the current state analysis was the inexistence of a common ERP system, which results in poor visibility between the parent company and subsidiaries. Without accurate and real-time data, it was impossible to make data-driven decisions

**Table 1** Issues Based on Current State Analysis

Challenge(s) and development need(s)	Implication(s)
No common ERP system.	Transparency and data-driven business making challenging.
No real-time and accurate inventory data.	No visibility regarding inventory levels, knowledge-based management hard.
No common and documented practices for inventory management and control.	Subjective decision-making, no continuity.
Diffused and defective inventory management organisation.	Daily operative inventory work challenging, defective division of responsibility, collaboration not exploited.
No reporting of inventories.	Visibility regarding operative level and information flow poor.
Shortage of free space and disorder in the inventories.	Extra time spent on finding items, safety risks.
High level of non-marketable items.	High inventory levels, added costs, lack of free space.
Information related to inventories strongly person bound.	Risk of losing information.
Diffused inventory locations.	Travelling between inventories.
A lot of manual work.	Overall inefficiency, no utilisation of technology.

for optimising inventory levels. In the corporation context, the importance of data is essential as there are more needs to be met and, naturally, more information to deal with. Without common ERP, collaboration inside the corporation is harder, and the barriers are higher not only in inventory management but also in other business operations.

As inventories were not centralised and their locations were diffused, a lot of travelling and overall effort was required in order to utilise the inventories. In the case company, some of the subsidiaries had to exploit each other's inventories for daily operative work. As the general rules for managing inventories were not properly documented and followed, the disorder in the inventories kept on growing. The lack of documentation and people focusing on inventory management made it difficult to keep the inventories up-to-date and efficient. Development work and efforts were not conducted. Hence, the importance of organisation and jointly approved processes in inventory management cannot be underestimated. This is highlighted in the corporation environment as the users of inventories can vary significantly. When the need to use part of the inventory appears, the overall process for retrieving an item must be visible and clear.

Overall, the inventory management in the case organisation was sub-optimised even though the subsidiaries had a need for collaboration related

to utilising the inventories. The importance of real-time and transparent inventory data, inventory-focused personnel for operative control and development work and commonly agreed upon and visible inventory management practices must be emphasised. In general, all the aspects described in the literature review of this study have effects on inventory management and its development. As the corporation environment has special characteristics, such as a large variety of needs to be met, the shortages in inventory management practices are emphasised and result in overall inefficiency in the corporation's everyday work.

## **Discussion**

This study focused on inventory management challenges in a corporation context. A literature review on the elements of efficient inventory management provided the framework for the study. Next, a current state analysis was conducted, and challenges and development needs related to the case organisation's inventory management were identified. In this section, the study's findings are discussed from theoretical and managerial perspectives.

The results of the study indicated a large number of inventory management challenges in a corporation (Table 1). These challenges were strongly related and divided into three categories according to the literature review: supply chain and materials management, information systems and the organisation of management and personnel. The lack of real-time inventory data, the non-existence of commonly agreed upon and visible inventory management practices and defective inventory management organisation all resulted in disorder in geographically diffused inventories, poor transparency inside the corporation and overall inefficiencies.

The corporation context adds more unique requirements for inventory management as the number of different stakeholders grows, the environment expands and more demands emerge, which all make inventory management more complex. In this context, the importance of common data, processes and people responsible for corporation-level inventory management are highlighted.

## **Theoretical Implications**

The current state analysis identified many challenges related to the case organisation's inventory management practices. The key findings of our study highlight the importance of reliable inventory data, documented inventory management practices and unified inventory management organisation to improve operational efficiency. Inventory management is a key part of supply chain and logistics efficiency (Lummus & Vokurka, 1999; Silver et al., 1998), and therefore, the inventory management impacts the whole

business. In the corporation context, all the inventory types presented by Richards (2018) exist, and as a result, the reasons for building stock are extensive in order to satisfy the different needs within the corporation. Strijbosch et al. (2000) argues that an advanced forecasting and inventory control approach provides a good service level in many circumstances, whereas a simple approach may lead to larger inventories in order to meet the required service level. The findings of our study also indicate that the corporation's inventories contain many types of items with different demand patterns, which may create a need for tailored control approaches.

As the environment and needs expand, the importance of supply chain and materials management, information systems and the organisation of management and personnel grows. The common materials management practices and rules presented by Lambert et al. (1998) and Van den Berg and Zijm (1999) must be documented and standardised. Also, in cases where the inventory data are insufficient, knowledge-based management and decision-making is challenging. Chu et al. (2008) propose an advanced ABC-method that provides high accuracy of classification. However, the findings of our study indicate that insufficient inventory data can make even a simple ABC analysis difficult to execute. Thus, optimising the inventory levels can be difficult.

As observed by Kannan et al. (2013), developing inventory management can bring many benefits, such as decreased costs and increased profits. Our study indicates that achieving these benefits requires the harmonisation of inventory management practices. This requires corporation-level instructions for handling materials in the inventories and the adoption of the 5S method (i.e. sort, set in order, shine, standardise and sustain) for improved organisation and standardisation. In addition to the 5S method, the use of visual control can be considered (Majava et al., 2019; Majava & Ojanperä, 2017). This would also enable a reduction in the number of inventories and the combining of the items stored in them. In addition, a systematic approach is vital for success, and efficient BPM (Lee & Dale, 1998; Yingling, 1997; Zairi, 1997) requires re-organisation. With re-organisation and new organisational structures focused on developing and executing operative inventory management, the set objectives would be easier to achieve in some cases. Organisations also need KPIs for developing their processes and practices (Johnson & McGinnis, 2010). In addition, information systems and data are very important in the business process development (Zairi, 1997). The findings of our study stress the importance of KPIs, as observed also by Johnson & McGinnis (2010).

The ultimate goal in modern inventory management should be a data-driven organisation, enabled by common ERP, with a definition of its inventory processes and the creation of inventory-focused management. Our

study's results support the findings by Jääskeläinen & Luukkanen (2017) who argue that that middle managers' work is affected by informal controls and relies in many cases on individual intuition and judgment based on experience, rather than performance information or formal instructions. As the corporation context demands more exact information in order to achieve knowledge-based management instead of the making of intuitive decisions (Jääskeläinen & Luukkanen, 2017; Strijbosch et al., 2000), the need for ERP and generic development work are obvious.

### **Managerial Implications**

In this study, the challenges found related to inventory management are quite elementary and result in overall inefficiency in the corporation's everyday work. The current challenges set a good example of the importance of the different elements concerning efficient inventory management introduced in the literature review. For example, if the usage of information systems and exact data regarding inventory levels is defective, knowledge-based decision-making is almost impossible, and therefore, the optimisation of inventory levels is more difficult. This applies to both single companies and corporations where, as mentioned, the needs and motives for storing can vary a lot. Without common rules and procedures, which are followed by inventory personnel, everyday operative work is difficult to perform. In addition, as development work and continuous improvement are essential for ensuring overall efficiency, the importance of inventory-oriented personnel and top management initiatives for improving inventory management practices cannot be underestimated.

The results of this study cannot be directly generalised to other companies and corporations because the challenges and inventory maturity levels can differ a lot from one situation to another. However, this study highlights the fact that without the elements of efficient inventory management, the challenges can lead to diffused inventories, which are ineffective and do not support the business of the organisation. It is also notable that, as the corporation environment is a very broad one, the development work should be given time, and it should be ensured that the moves made during the development project support the set objectives and business strategy.

### **Conclusions**

Inventories have a remarkable effect on companies' businesses as they affect the overall supply chain and logistics efficiency. As inventories themselves add costs, inventory optimisation is vital in order to minimise costs but at the same time ensure a suitable level of service.

In the study, a current state analysis was conducted, and related challenges and development needs were analysed. The literature review acted



as a base for understanding the big picture in terms of the elements affecting efficient inventory management. The main challenges in the studied corporation inventory management were the lack of exact and accurate inventory data, the non-existence of common and visible documented practices for managing inventories and defective inventory management organisation for the daily control and development of inventories. These challenges led to overall inefficiency in the corporation.

In a corporation environment, shortages of the elements needed for efficient inventory management become more visible. Without common inventory data, collaboration between the companies inside the corporation related to the inventories and their use is challenging to execute. As different stakeholders inside the corporation utilise other companies' inventories, transparency and common rules for controlling the inventories should exist. If this is not the case, decision-making is subjective, and operative work performed in the inventories is not uniform. In addition, the lack of corporation-level inventory management personnel may result in the lack of development work at the corporation and subsidiary levels. These types of shortages lead to diffused inventories and overall inefficiency.

This study has the typical limitations of a single case study, for example, generalisability, validity and reliability concerns. The interviews related to current inventory management practices were recorded and validated after the interviews. Information systems data were analysed with great caution as the systems were defective, and therefore, the data were mostly incorrect. Finally, this study illustrated the challenges in terms of a low maturity inventory management level in a corporation context. In addition to studying different types of contexts and business sectors, potential future research could focus on implementing development work in corporations' supplies inventories and its effect on businesses.

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# Preventing Corporate Turnarounds through an Early Warning System

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Bankruptcy proceedings of companies have been all but new phenomena in the business world. Latest cases, encompassing Toys R Us, Fred's, and Sears in the US as well as Thomas Cook and Air Italy in Europe, demonstrate that managers often fail to run their businesses properly. As an alternative in such a case, managers could prevent potential downfalls through knowledge of a successful turnaround management. Learning about the implementation of an early warning system (EWS) might help avoid corporate turnarounds in the first place. Hence, it is crucial to offer managers a pragmatic and solution-oriented approach. That being said, the authors design a specific EWS that might contribute to bypassing corporate turnarounds at an early stage. By doing so, the article aims at disseminating information on better EWS for public corporations.

*Keywords:* early warning system, turnaround management, financial ratios

## Introduction

Over the last years, Fred's, Toys R Us, Forever 21, Diesel USA and other retailers in the US filed for bankruptcy. One of those filing for Chapter 11 was Sears, a more than a century old US retailer. Other such examples, like Thomas Cook and Air Italy in Europe show that not only retailers but also other company types face the risk of vanishing into thin air.

In earlier times in Europe, individuals who went bankrupt, often experienced a form of humiliation. For example, in the Italian city of Padua, the law foresaw that the individuals concerned had to appear in the palace of justice, in front of a rock of shame, to publicly declare bankruptcy. Nowadays, however, bankruptcy poses a too little social stigma, according to Sullivan et al. (2006). Therefore, it is not surprising that failures in corporations have been documented widely in the literature, as shown by Hofer (1980), Coleman (2004), and Lymbersky (2011), and concern not only private but also public organisations, as pointed out by Boyne (2004, 2006), and Cornforth and Paton (2004).

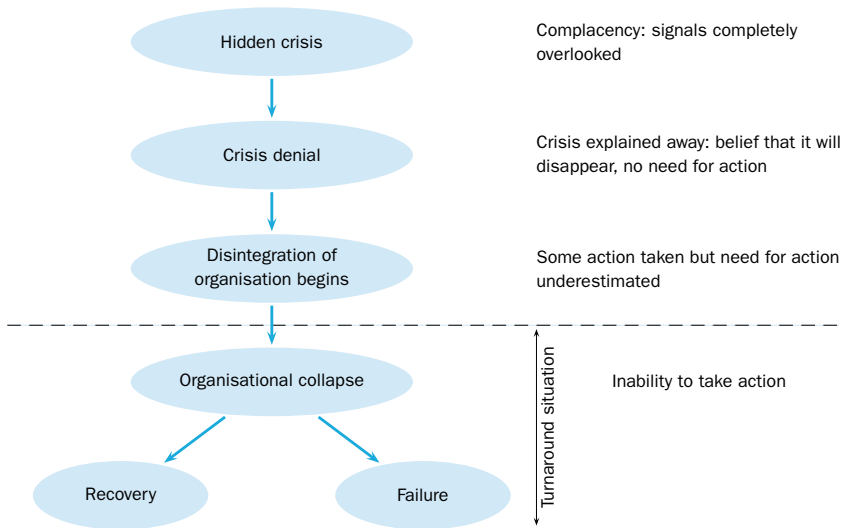
No company is entirely immune against economic distress and there seemingly is an aura of inevitability concerning eventual organisational failure. In many cases, as Slatter and Lovett (1999), Collard (2002), Faulhaber and Grabow (2009), Müller (2013), and Pepels (2015b) indicate, this stems from ignoring the signs of looming crises. In this context, early warning signals are frequently misinterpreted or hushed because of the unwillingness of the management to admit that their strategy is failing. Far too often it is only intervened when the liquidity and the continued existence of the company is already threatened, as displayed by Slatter and Lovett (1999).

Knowledge can be considered as a competitive advantage (Grant, 1997), as well as a substantial resource of companies (Polanyi, 1966). And yet its impact on innovation to tackle entrepreneurial challenges cannot be overestimated (Nonaka, 1994; Seidler-de Alwis and Hartmann, 2008). However, creating new knowledge constitutes a dynamic interplay between individuals and organisations, encompassing a high degree of context, such as specific time and space (Nonaka et al., 2000), that might lead to a journey 'from being to becoming' (Prigogine, 1980).

As history shows, management often underestimates the strategic change in the wake of business turnarounds. Trying to avoid learning the wrong lessons from history, the authors seek to reveal key factors that can lead to firms escaping from a potential failure (Wild, 2010). To protect the management from corporate failures better, the work presents a system, which might prevent corporate turnarounds in the first place. Hence, the authors test the most prominently discussed crisis recognition tools on several case studies to create an early warning system (EWS), enabling companies to detect potential symptoms at an early stage.

### Literature Review

While there has been a large body of research in view of corporate turnarounds, such as from Schendel et al. (1976), Schendel and Patton (1976), Bibeault (1998), Vinten et al. (2005), the subject of early crisis recognition, despite its practical significance, has not been a major focus of researchers in the past. The focus was put more on establishing a general approach and techniques for turnarounds, as noted by Slatter and Lovett (1999), and Platt (1998), or addressing the topic from a more specific standpoint. Slatter et al. (2006) concentrated on leadership during turnarounds, whereas Driendl (2012) looked at turnarounds from a stock market perspective and set out how profitable some turnaround stocks might become. Others dealt with identification of distinct turnaround strategies, as, for example, for small firms by Boyle and Desai (1991), restaurants, as displayed by Chathoth et al. (2006), hospitals, shown by



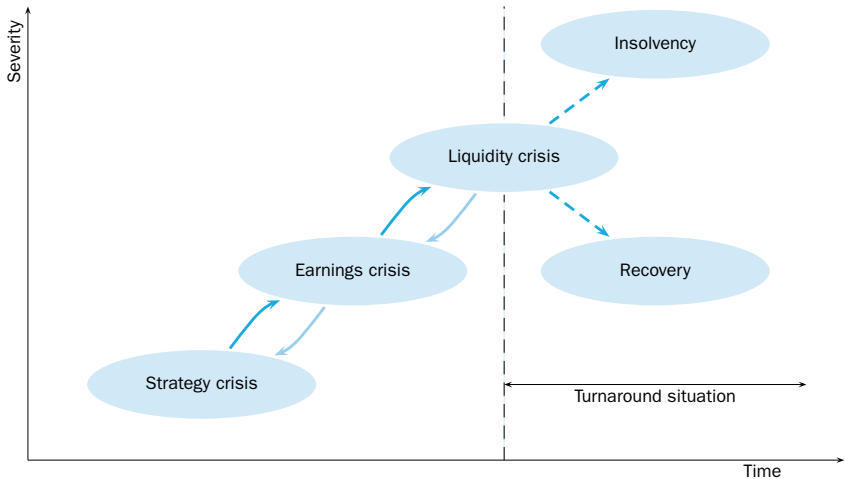
**Figure 1.** Four Stages of Crisis Development, according to Slatter and Lovett (1999)

Langabeer (2008), or industrial business units, as pointed out through Hambrick and Schechter (1983).

Organisational crises usually develop according to the four-stage model by Slatter and Lovett (1999), as shown in Figure 1. According to it, the internal recognition that a company is in trouble usually comes as a surprise, despite the crisis being triggered long before. Schendel et al. (1976) define a turnaround situation as a low-probability and longer lasting, high-impact situation leading to a decline in performance. However, challenges faced are often ill defined and lack a single solution path, as note by Mumford et al. (2000).

In general, a turnaround situation occurs as soon as corporate survival is doubtful. Once such a state is apparent, corrective measures must be taken to salvage the company from bankruptcy, as Slatter and Lovett (1999) point out. As soon as an organisation regresses into a turnaround situation, long-term strategic planning recedes into the background, and ad-hoc management measures are employed to try to turn the situation around. Therefore, turnarounds pose stressful situations for a corporation, as Finkin (1987), Faulhaber and Grabow (2009), and Marti (2013) show, owing to ad-hoc corrective measures, which usually divert personnel from routine tasks. Additionally, highlighted by Lenahan (1999), the use of external resources often escalates the already considerable costs of the event and many companies fail to execute a successful turnaround and go bankrupt.

Turnaround management includes all activities undertaken by an organi-



**Figure 2** Emergence and Recognition of Organisational Crises, as shown by Bichkoff and Eilenberger (2004), Evertz and Krystek (2014), and Müller (2013)

sation in an existence-threatening state, to avert impending insolvency and return to sustainable profitability, as Buschmann (2006), Driendl (2012), and Pepels (2015a) note.

Building on this model, research generally distinguishes between three types of organisational crises of increasing severity, as illustrated in Figure 2. A strategy crisis is less serious than an earnings or liquidity crisis and thus accompanied by less obvious signs. The longer a crisis remains uncontrolled, the more severe it gets and the more obvious the warning signs become. Far too often, crises are not acknowledged until the liquidity of the company is endangered (Müller, 2013). This is highlighted by the arrows in Figure 2, as light arrows show the order of recognition and dark arrows the order of emergence.

Since the crisis types continuously progress over time, the importance of early recognition can be highlighted. Furthermore, it challenges the notion indicated by Platt (1998) and Pepels (2015a), where long-term strategic planning is not considered the highest priority during a corporate turnaround and the concerns about the future and longevity of the company are replaced by the immediate objective of saving the company from insolvency. Such a focus reinforces the application of methods such as cost-cutting, asset reduction or downsizing is, which often only lead to short-lived stabilisation of the business, as Slatter et al. (2006) shows.

Consequently, researchers have recognised the pitfalls to this being the sole measure of turnaround success and directed the attention towards the sustainability of such endeavours, like authors, such as Barker



and Duhaime (1997), Bickhoff and Eilenberger (2004), and Faulhaber and Grabow (2009), suggest.

Given the availability and relevance in business failure prediction, *financial ratios* are frequently used as crisis indicators, as Platt (1998), Situm (2013), and Zopounidis and Doumpou (1999) note. Further, *discriminant analyses* (Altman, 1968) and *logistic regressions* (Situm, 2013) both also building on multiple financial ratios, have commonly been used to evaluate financial health. The main caveat of the application of ratio-based analyses is that financial statements could be subject to creative accounting, and thus may provide a distorted picture of the company accounts and the severity of the crisis. The risk can partly be mitigated by relying on data from annually prepared statements, as they are audited and provide a more truthful view (Platt, 1998). Additionally, there is a high possibility that there is a time lag between the internal occurrence and external recognition of the crisis as most audited financial reports are published annually (Slatter & Lovett, 1999).

### Methodology

The broad EWS created for the analysis of the case studies consists of specific ratio analyses, Altman's (1968) discriminate model and Doumpou and Zopounidis' (1999) logistic regression. Appendix shows the formulas of how the different EWS scores are calculated. The framework is applied to several case studies and is tested on its predictive abilities. The cases have been selected based on the presence of a crisis, the availability of financial information, as well as the inclusion of various industries. The investigated timespan has also been subject to the availability of financial information. The analysis will consist of a thorough evaluation of the specific companies' financial performance over various fiscal periods. The results are displayed in a radar chart, where the changes in each measurement can be traced and interpreted.

The figures are interpreted based on the changes in each measurement and the predictive ability of different measurements is assessed. In doing so, the final framework can be condensed to the few most decisive measurements. The ratios used in subsequent analysis have been selected based on their ability to predict crisis situations and their prominent use in past research. The selected ratios were, with the exception of the quick ratio and ROE, used by more than one third of the sources analysed. The ROE has been specifically taken into consideration because of its ability to illustrate the impact of debt on the generated return when compared with the ROA (Leach, 2010). The quick ratio has been added to the analysis due to its capability to quantify the impact of accumulation of inventory on a firm's ability to cover all its short-term liabilities (Leach, 2010).

**Table 1** Scale Determinants

	(1)		(2)		Debt ratio	
	Lowest	Highest	Lowest	Highest	Lowest	Highest
BlackBerry	0.447	5.027	-0.186	1.166	0.111	0.520
Bristol-Myers Squibb	2.460	14.188	0.059	0.550	0.478	0.665
General Electric	0.487	2.041	-0.001	0.058	0.774	0.835
Rolls-Royce	3.401	12.903	0.054	0.110	0.663	1.033
	Current ratio		Quick ratio		ROA	
	Lowest	Highest	Lowest	Highest	Lowest	Highest
BlackBerry	2.059	6.489	1.779	6.284	-77.8%	26.5%
Bristol-Myers Squibb	1.150	2.210	0.947	1.987	-5.4%	34.2%
General Electric	1.625	3.570	1.410	3.417	-7.3%	2.4%
Rolls-Royce	1.202	1.485	0.793	1.160	-15.8%	14.4%
	ROE		Z-score		Logit model	
	Lowest	Highest	Lowest	Highest	Lowest	Highest
BlackBerry	-162.0%	32.9%	-0.557	25.454	0.0%	100.0%
Bristol-Myers Squibb	14.4%	71.5%	3.152	9.469	90.3%	100.0%
General Electric	-4.4%	12.2%	1.054	1.879	0.1%	15.9%
Rolls-Royce	-228.0%	68.2%	0.212	1.850	0.0%	99.9%

**Notes** (1) working capital turnover, (2) cash flow to debt ratio.

This work uses Altman's (1968) multiple discriminant analysis to predict corporate turnaround situations. Due to the model discriminating between bankrupt (score below 1.81) and non-bankrupt firms (score above 2.67), negative changes in the Z value reflect underlying problems within the organisation and thus warn of imminent crisis situations. Negative changes in the score can be seen as an early indicator for a potential crisis, even if the score lies far above the grey area.

The logit model is also based on financial ratios, but, unlike Altman's (1968) Z-score, its foundation is a logistic regression and includes different parameters, according to Situm (2013). Research shows that it is one of the main alternatives to Altman's (1968) discriminant analysis and overcomes some of its limitations, as demonstrated by Doumpou and Zopounidis (1999), and Situm (2013). According to the latter, the most prominent advantage is that it indicates a company's probability of financial health. In brief, when a company achieves a score of 82 per cent, it shows an 82 per cent probability to be in a healthy financial situation. Were the score to drop below 78 per cent, a firm is considered financially stricken (Situm, 2013).

Since all employed tools yield a different result that can only be interpreted on its specific scale, all figures need to be converted to a single scale in order to be compared to one another. Therefore, this work first determined the acceptable ranges for each ratio and converted those to

a single 0 to 10 scale, where 0 is the lowest (worst) and 10 the highest (best) score. The acceptable ranges are based on the highest and lowest scores in the respective ratio across all case studies, which are adjusted if the scores are deemed outliers, see Scale Determinants in Table 1.

In cases where the score exceeds the set range, they are fixed on either lowest or highest range score respectively in order to facilitate interpretation of the results. To convert the figures to the radar scale, a conversion function for each specific measurement was established, as displayed below. The variable  $x_1$  stands for the initial ratio result, whereas  $x_2$  shows the results on the radar scale. If the working capital turnover, for example, was 4.0 for any case study, the score shown on the ratio scale would be 5.8, as given by its specific scale conversion function.

### Formulas for Conversion to Radar Scale

$$\text{Working capital turnover } x_2 = \frac{x_1 + 25}{5}$$

$$\text{Cash flow to debt ratio } x_2 = \frac{x_1 + 0.5}{0.2}$$

$$\text{Debt ratio } x_2 = \frac{x_1 - 1.5}{-0.15}$$

$$\text{Current ratio } x_2 = 2x_1$$

$$\text{Quick ratio } x_2 = 2x_1$$

$$\text{ROA } x_2 = \frac{x_1 + 20}{6}$$

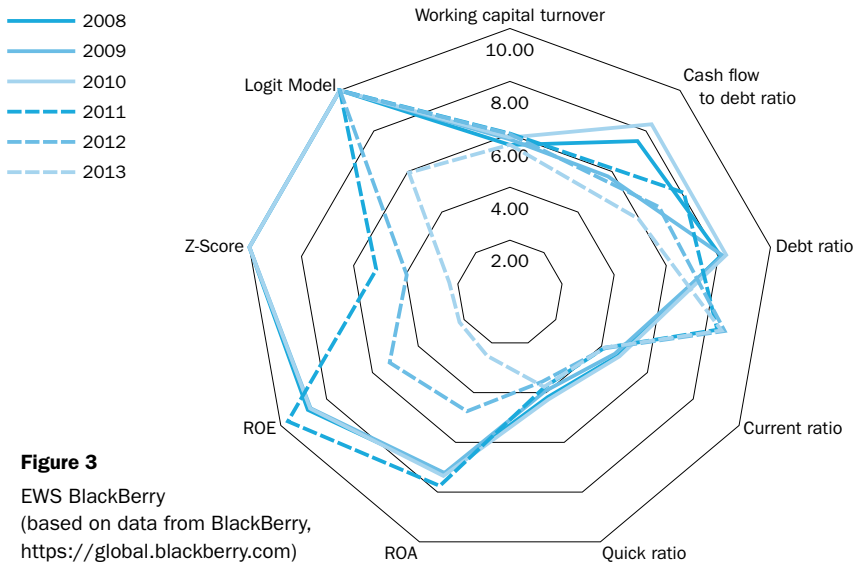
$$\text{ROE } x_2 = \frac{x_1 + 20}{6}$$

$$\text{Z-score } x_2 = x_1$$

$$\text{Logit model } x_2 = \frac{x_1}{10 \times 100}$$

### Analysis

The findings of the analysis are presented in a coherent manner. The results of the EWS model applications to what is deemed the relevant timespan for early crisis recognition are illustrated, and the development of each measurement score is assessed. To increase the understanding, the calculated scores and their radar score equivalent have been given in squared brackets [ratio value/radar score]. By applying the framework from the literature review to case studies, the applicability of the different parameters in terms of early crisis recognition is evaluated.



### BlackBerry

**Activity.** The organisational efficiency, as measured by the working capital turnover, continuously increased from 2008 [3.00/5.60] to 2011 [5.16/6.03]. In the following year, there was a marginal decrease in the ratio [5.03/6.02], followed by substantial decrease in 2013 [3.03/5.61]. The working capital turnover has been decreasing ever since, falling below 1 in 2018.

**Coverage.** The cash flow to debt ratio shows the first considerable decline between 2008 [1.00/7.50] and 2009 [0.65/5.76]. In the following period, the ratio nearly doubled [1.17/8.33], before beginning to decrease again in 2011 [1.02/7.59]. In the 2012 fiscal year [0.80/6.51], a further decline in the coverage ratio can be recognised. The negative trend continued, and the ratio dropped by nearly 40 percent until 2013 [0.62/5.61]. In 2014, the operating cash flow coverage became negative.

**Leverage.** The debt ratio changed only marginally over the assessed period from 2008 [0.29/8.09] to 2013 [0.28/8.12]. The debt ratio initially decreased until 2010 [0.25/8.30], showing an increasingly less risky financial situation for BlackBerry. Beside a small spark in the ratio in 2011 [0.31/7.96], marking the highest level of debt for the recognition-relevant time period, the debt level increased rather drastically thereafter.

**Liquidity.** The quick and current ratios improved from 2008 [Current: 2.36/4.72; Quick: 2.08/4.18] until 2010 [Current: 2.39/4.78; Quick: 2.13/4.27] and began to drop in 2011 [Current: 2.06/4.13; Quick: 1.89/3.79]. Both ratios remained roughly on the same level for the rest of the times-

pan. Overall, the liquidity ratios stayed above their respective limits, which implies financial health for the whole recognition-relevant period.

*Profitability.* In the beginning, the ratios slightly declined from 2008 [ROA: 23.5/7.25; ROE: 32.9/8.70] to 2009 [ROA: 23.4/7.23; ROE: 32.2/8.70]. From there on, the ratios improved until 2011 [ROA: 26.5/7.75; ROE: 38.2/9.69], before plummeting by nearly 75 per cent in 2012 [ROA: 8.48/4.75; ROE: 11.5/5.25] and becoming negative in 2013 [ROA: -4.91/2.52; ROE: -6.83/2.20]. BlackBerry continued to generate negative profits until the 2018 fiscal period.

*Discriminant and Logit Analysis.* The logit score remained above 99 per cent until 2013 [59.4%/5.94], where it fell notably, indicating the presence of a turnaround situation. The score fell further to 0 percent in the following fiscal year, which indicates a 100 percent probability that BlackBerry was in financial troubles. In 2010 [12.0/10], the Z-score was still above the upper limit of the radar scale, but decreased by more than 50 per cent in 2011 [5.13/5.13]. This worrying development continued, and the Z-value fell further until 2013 [2.33/2.33] and even became negative in 2014.

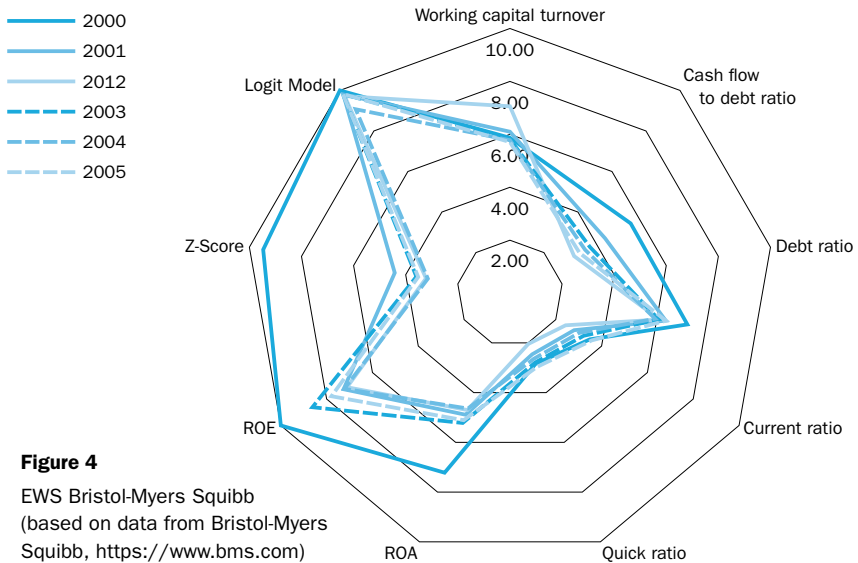
### **Bristol-Myers Squibb**

*Activity.* The working capital turnover of Bristol-Myers Squibb has improved drastically between 2000 [4.35/5.87] and 2002 [10.3/7.06], and the ratio more than doubled. In the subsequent year [4.11/5.82], the ratio plummeted lower than the 2000 level and further decreased until 2005 [3.56/5.71]. Consequently, while the capital was managed increasingly more efficiently until 2002, the notable drop in efficiency in 2003 indicates serious underlying issues within the organisation.

*Coverage.* The cash flow to debt ratio decreased remarkably in the first two years, from [0.55/5.27] in 2000 to [0.06/2.80] in 2002. This shows that by 2002, at the lowest point of the year-end stock price development, Bristol-Myers Squibb could only cover six per cent of its debt with its operating cash flow. The ratio then improved remarkably in 2003 [0.20/3.49], before declining in 2004 [0.16/3.28] and 2005 [0.11/3.04].

*Leverage.* The debt ratio in the Bristol-Myers Squibb example shows a substantial increase in the first five fiscal periods from [0.48/6.81] in 2000 to [0.66/5.57] in 2004. This indicates that an increasingly higher proportion of the invested funds was raised from liabilities. In 2005 [0.60/5.99], the ratio began to decrease again.

*Liquidity.* Since both liquidity ratios remained above 1 for the entire period, they do not indicate grave liquidity issues. Both ratios decreased in the first three years, from 2000 [Current: 1.74/3.49; Quick: 1.42/2.84] to 2002 [Current: 1.21/2.43; Quick: 1.02/2.04]. Subsequently, the current and quick ratio both increased until 2005 [Current: 1.78/3.57; Quick:



**Figure 4**

EWS Bristol-Myers Squibb  
(based on data from Bristol-Myers Squibb, <https://www.bms.com>)

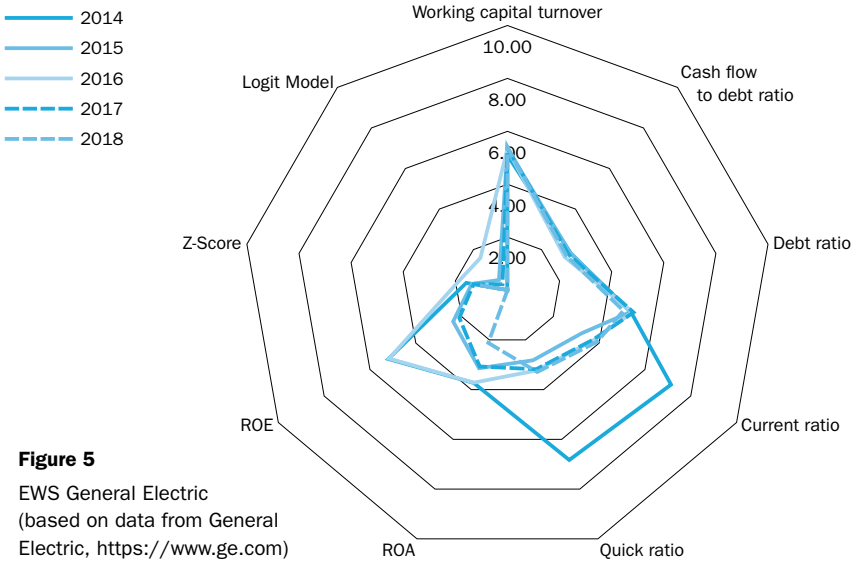
1.48/2.97], with shortly decreasing in 2004 [Current: 1.50/3.01; Quick: 1.32/2.64].

*Profitability.* Overall, the pharmaceutical industry is extremely profitable, which is shown by Bristol-Myers Squibb achieving a ROA of up to 34 per cent and a ROE of over 70 per cent in 2009. During the assessed period, profitability initially decreased drastically between 2000 [ROA: 23.3/7.22; ROE: 44.6/10] and 2001 [ROA: 9.34/4.89; ROE: 23.4/7.26]. In the following two periods, Bristol-Myer Squibb achieved an increase in profitability until 2003 [ROA: 11.3/5.22; ROE: 31.7/8.62], before it dropped in 2004 [ROA: 7.85/4.64; ROE: 23.4/7.23] and rose again to similar heights in 2005 [ROA: 10.7/5.11; ROE: 26.8/7.79]. Overall, there is a distinct negative development over the recognition timespan, which serves as an indicator for the struggles Bristol-Myers Squibb faced during this period.

*Discriminant and Logit Analysis.* The Z-score shows the same pattern as the profitability ratios, as it decreased drastically from 2000 [9.47/9.47] to 2001 [4.42/4.42] and further declined in 2002 [3.22/3.22]. Thereafter, the score improved until 2005 [3.52/3.52], which shows that a potential crisis was tackled accordingly. The logit score never indicated the presence of a turnaround situation, as the lowest point in 2004 [90.7%/9.07] remained far above the 78 per cent limit. Hence, the company never faced liquidity troubles during the organisational decay.

### General Electric

*Activity.* The working capital turnover increased in the analysed timespan from 2014 [0.50/5.10] to 2018 [2.04/5.41]. The remarkable increase



shows that the working capital is progressively employed more efficiently, despite the company suffering from a major stock price decline. The drastic increase from 2014 [0.50/5.10] to 2015 [1.79/5.35] may have increased management optimism regarding the future prospects of the firm, since it correlated with the initial stock price improvement.

**Coverage.** The cash flow coverage was already extremely poor in 2014 [0.05/2.77], remained on the same level in 2015 [0.05/2.76], before it became negative in 2016 [-0.0009/2.50]. In the following fiscal period in 2017 [0.04/2.68], it improved to around 4 per cent, only to plummet again in 2018 [0.02/2.58]. Overall, at no point during the examined timespan was the operating cash flow covering more than five per cent of the total liabilities of General Electric.

**Leverage.** There was small net increase in the debt ratio from 2014 [0.79/4.74] to 2018 [0.83/4.45], which shows that the financial situation of General Electric became riskier in the course of the corporate decay. However, this is only reflected in a marginal increase and the ratio remained roughly on the same level throughout the assessed period.

**Liquidity.** Both ratios decreased remarkably by more than 50 per cent between 2014 [Current: 3.57/7.14; Quick: 3.42/6.83] and 2015 [Current: 1.63/3.25; Quick: 1.41/2.82]. In the following years, both ratios gradually increased again until the most recent fiscal year [Current: 1.96/3.91; Quick: 1.65/3.29], without ever approaching similar values as in 2014.

**Profitability.** While the profitability initially increased until 2014 [ROA: 2.37/3.73; ROE 11.2/5.20], it plummeted to negative figures in 2015 [ROA: -1.18/3.14; ROE: -5.79/2.37]. However, the fact that the profitabil-

ity recovered in 2016 [ROA: 2.34/3.72; ROE: 11.0/5.17] may have fostered the internal belief that the fall in corporate performance was only an evanescent issue. By again achieving negative profits in 2017 [ROA: -1.6/3.07; ROE: -7.39/2.10] and further declining profitability in 2018 [ROA: -7.26/2.12; ROE: -43.6/0], the corporate crisis was likely to have been acknowledged.

*Discriminant and Logit Analysis.* While the net profits were still increasing between 2010 and 2014, the logit score was declining and showed a 0.07 per cent probability that General Electric was financially sound in 2014 [0.07%/0.01]. Although the score improved until 2016 [15.9%/1.59], the financial situation only improved marginally with the logit score still indicating imminent bankruptcy.

Furthermore, also the Z-score already showed the underlying troubles within General Electric in 2014 [1.58/1.58]. The score continuously decreased, with the exception of a spike 2016 [1.88/1.88], and reached its lowest point in 2018 [1.05/1.05].

### Rolls-Royce

*Activity.* While the working capital turnover marginally improved between 2012 [5.07/6.01] and 2013 [5.11/6.01], it plunged in 2014 [3.92/5.78] and further decreased in 2015 [3.48/5.70]. In the following fiscal period [4.50/5.90], the working capital was employed more efficiently again. The increase in the WC turnover possibly indicates that the previously existing problems have been overcome.

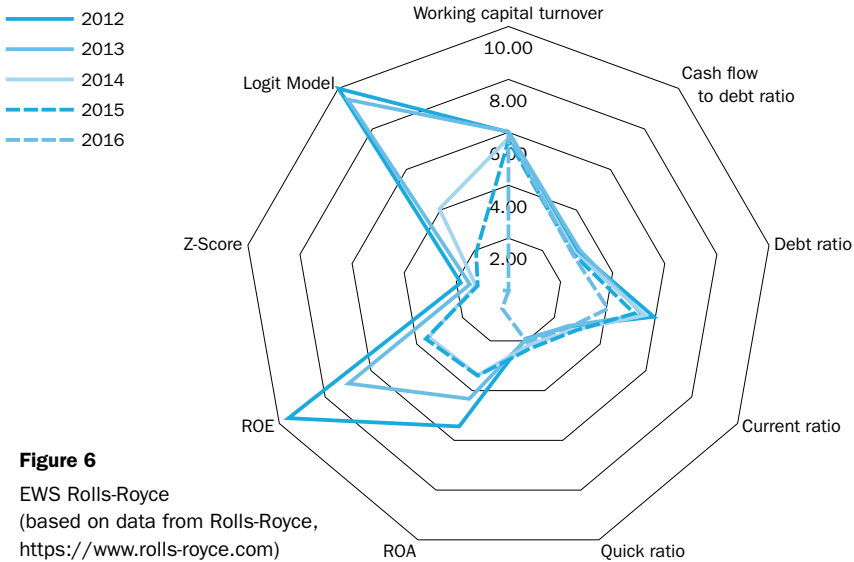
*Coverage.* The cash flow to debt ratio showed an initial increase from [0.10/3.02] in 2012 to [0.12/3.11] in 2013, before falling to [0.08/2.91] in 2014. In the following two fiscal years, the coverage ratio further declined until reaching [0.06/2.80] in 2016. Consequently, it can be recognised that the cash flow coverage of the total liabilities progressively decreased over the analysed timespan.

*Leverage.* The debt ratio continuously increased from [0.66/5.58] in 2012 to [0.71/5.25] in 2014, to [0.93/3.82] in 2016. This progressive incline in the debt ratio implies that financial situation of Rolls-Royce has become increasingly riskier over the course of the analysis, as the proportion of assets financed by debt increased remarkably.

*Liquidity.* The liquidity ratios increased in the first four years from 2012 [Current: 1.33/2.67; Quick: 0.95/1.91] to 2015 [Current: 1.48/2.96; Quick: 1.16/2.96], which implies that Rolls-Royce's ability to cover its current liabilities increased during this period. In 2016 [Current: 1.35/2.70; Quick: 1.02/2.70], both ratios decreased and have been declining ever since.

*Profitability.* 2012 [ROA: 12.7/5.44; ROE: 37.6/9.60] was an outlier





year regarding Rolls-Royce's profitability as it skyrocketed. Subsequently, the ratios decreased by more than 50 per cent in 2013 [ROA: 5.80/4.33; ROE: 21.9/6.98] and further plummeted in 2014 [ROA: 0.21/3.38; ROE: 0.91/3.48]. A slight increase in 2015 [ROA: 0.38/3.40; ROE: 1.67/3.61] was answered by negative profitability ratios in 2016 [ROA: -15.8/0.70; ROE: -216/0].

In the following years, the ratios fluctuated immensely between high returns in one period and negative returns in another. The annual statement shows that the outlier year in 2012 could have been due to restructuring a business unit, as noted by Rolls-Royce (2013).

*Discriminant and Logit Analysis.* The corporate decay was signalled by a steadily declining Z-score from [1.83/1.83] in 2012 to [0.21/0.21] in 2016. The immense initial drop from 2012 [1.83/1.83] to 2013 [1.48/1.48] classified the company as insolvent, according to Altman's (1968) definition. By nearly reaching 0, the discriminant analysis indicates that Rolls-Royce was extremely close to organisational failure. The logit score shows a similar reality as in other case studies. Subsequently to the Z-score declining in 2013, the logit model indicated a 40.6 per cent chance of financial health in 2014 [40.6%/4.06].

In the previous two years, the ratio only declined marginally from 2012 [99.9%/9.99] to 2013 [94.5%/9.45]. After already indicating financial troubles in 2014, the logit score further declined to 0 per cent in 2016 [0.00%/0].

## Results

### *BlackBerry*

In the BlackBerry case, the crisis transitioned to an earnings crisis in 2012, as the net income began to be affected. In the following year, the logit score indicated a shift towards liquidity crisis. According to the theory, it can be assumed that the crisis was recognised as soon as the first losses occurred in 2013.

Although the falling stock price may have already raised awareness of a potential crisis in 2011, the consequent period of continuous growth hints at optimism potentially still being the prevailing management rhetoric at the time. The EWS framework clearly indicated the deteriorating situation two years before the solvency of the firm became endangered, as the declining Z-score in 2011 should have already caused serious concern among BlackBerry's top management. In the following year, the falling profitability, combined with the decreasing coverage ratio, further underlined the increasing severity of the symptoms.

### *Bristol-Myers Squibb*

The company's net income hardly declined over the period. Plus, the liquidity was never endangered either. It appears that the crisis was recognised in due time, since the strategy crisis never transitioned to the next crisis stage. The application of the system reveals that the first concerning signs became visible in 2001, when the Z-score decreased substantially. Therefore, the framework hints at an imminent turnaround situation one year before the crisis was arguably recognised due to the fall in the year-end stock price.

However, it can be assumed that corrective measures were taken accordingly, stopping the organisational decay as the earnings or liquidity situation of Bristol-Myers Squibb never was affected. Moreover, the fact that most of the scores improved in 2005 possibly indicates that the measures have been successful. Without such action, the logit score would have arguably decreased further in the following years, potentially indicating a turnaround situation. As a result, this case serves as an example of how the early recognition of a looming crisis can lead to a timely resolution.

### *General Electric*

GE's discriminant value only slightly surpassed the proposed lower limit of 1.81 in its outlier year in 2016. This short-lived improvement coincided with the highest stock price for the complete timespan. The General Electric case is somewhat an exception to the previously analysed cases, as the logit score and Z-value have indicated a crisis situation since the beginning

of the timeframe. Although the stock price was still achieving continuous growth, the underlying issues within the corporation became increasingly more visible.

A notable decrease in the liquidity, as well as the profitability ratios in 2015, further reinforced the existence of a corporate crisis even before the stock price plummeted. While the company generated net losses in 2015, fiscal results were probably seen as negative outliers, due to the subsequent increase in net revenues in 2016. This development is also recognised on the stock market and reflected in an additional increase in the stock price. Consequently, it can be argued that the existence of the crisis was not acknowledged until 2018, when the net losses increased more than threefold. Since the logit score was consistently indicating a turnaround situation, liquidity crisis was apparent, and the application of the model would not have predicted the crisis prior to affecting the solvency of the firm. However, since it can be argued that the crisis was not acknowledged until 2018, the EWS would have enabled the GE management to introduce corrective measures at least four fiscal periods prior to the crisis recognition.

### **Rolls-Royce**

In this case, the declining discriminant and logit results show that the imminent crisis became increasingly severe and reached the liquidity crisis stage in 2014. The decline in the logit score indicated this transition to the next crisis stage already in the previous year. Furthermore, it could even be argued, since the Z-score was never above 1.85 in any of the previous period, that the symptoms of the looming crisis were already visible six fiscal periods before the logit score indicated that Rolls-Royce's solvency was endangered. Consequently, the application of this model once again managed to show the underlying organisational issues, while the stock market was still largely optimistic.

### **Conclusion**

To conclude, the application of the EWS yielded clear results regarding the predictability of crisis situations. That said, based on the cases, the EWS was able to predict looming organisational crises on average 3.25 years prior to their occurrence. In many cases, crisis symptoms were already visible two or more years prior to either the liquidity being affected, or the crisis situation being recognised.

In the Rolls-Royce example, the signs should already have caused serious concerns six years prior to the crisis, whereas the General Electric case showed that the crisis could have been recognised four years earlier. In both cases the rising stock price indicated that the overall perception of

the company was still positive during a period where red flags were already visible.

The Bristol-Myers Squibb case reinforced the notion that crises are more easily rectified if they are recognised earlier. In general, the case studies have clearly shown that turnaround situations, as implied by a fall in the logit score, are predictable. In nearly all of the cases, the symptoms were evident before a turnaround situation was apparent. The first indicators of the looming decay are often a decline in the Z-value, followed by negative changes in the organisational profitability. The cash flow to debt ratio was in some cases more, and in others less meaningful.

Overall, neither the activity, leverage nor liquidity ratios were able to unambiguously indicate a negative trend development. Therefore, the proposed conceptual framework can be condensed to the most indicative factors, namely the Z-score, coverage and profitability ratios that signalled the looming crisis reliably. The logit score is further included in the final EWS because of its importance in defining the existence of a turnaround situation. In condensing the framework, its application and interpretation can be facilitated.

The aforementioned explanations provide strong evidence that all turnarounds are preventable, as long as they are predictable. For this to happen, an EWS is essential to guarantee both more time and alternatives to respond to the crisis. By applying an internal EWS, managers are enabled to identify challenges at an early stage. Thereby, the EWS allows the management to initiate counteractions to prevent the company from a potential bankruptcy filing. This might be, amongst a row of potential other measures, the launch of an internal investigation in view of the underlying issues causing the adverse effect on the company business.

Overall, it can be concluded that the created EWS is a step forward regarding crisis recognition and can possibly serve as the foundation for a more extensive framework in the future. Future studies should consider the application of the model in a practical environment to confirm the framework value in real-life situations. Further, they could take industry-specific aspects into consideration to enhance the quality of each scale provided. Following this, the illustration of the radar scales as well as its interpretation could be optimised. Finally, future works on this topic should concentrate on the integration of qualitative factors in the EWS framework. This, in turn, might help to recognise a looming threat to the organisation even earlier and potentially facilitate a stronger in-depth analysis regarding the reasons for deterioration.

The nature of the analysis applied is subject to the validity of publicly available financial statements. Since the annual reports only show the specific performance at the end of the fiscal years, the predictive abilities of

the framework may be restricted. Furthermore, it highlights one of the EWS weaknesses, which, as the case studies have revealed, points to the quick deterioration of specific situation of the company taking place from one year to another. The foregoing stands in opposition to the assumption of a rather slow and gradual decline.

However, for company internal applications of the EWS, this becomes less relevant as the monitoring of the scores can be performed on a more regular basis. Therefore, internal use would potentially allow for an even earlier crisis recognition, as the decline may appear less drastic if the scores are evaluated biannually or quarterly.

Additionally, the framework does not indicate why the analysed scores are changing or how the crisis could be overcome, due to the lack of qualitative parameters. It only indicates that there are organisational problems apparent, but is subject to further analysis of financial statements, macroeconomic- and company-specific factors in order to define the root causes of the organisational decay. The framework does not account for the prediction of crises due to unforeseeable events or fraudulent behaviour, as this arguably should be part of a company risk management rather than crisis prediction.

Lastly, all cases have been analysed retrospectively, which arguably makes it easier to determine negative trends. Consequently, it could be argued that while the developments seem obvious in past cases, the application of the framework in real time would not yield similar results. Therefore, the capabilities of the EWS, when applied in practice, still need to be verified, but based on the clear results, a successful transition to corporate application could be expected.

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**Appendix 1: Formula Directory**

**Financial Ratios**

$$\begin{aligned} \text{Activity Ratio} \quad \text{Working capital turnover} &= \frac{\text{Sales revenue}}{\text{Net working capital}} \\ \text{Coverage Ratio} \quad \text{Cash flow to debt ratio} &= \frac{\text{Operating cash flow}}{\text{Total debt}} \\ \text{Leverage Ratio} \quad \text{Debt ratio} &= \frac{\text{Total debt}}{\text{Total assets}} \\ \text{Liquidity Ratio} \quad \text{Current ratio} &= \frac{\text{Current assets}}{\text{Current liabilities}} \\ \text{Liquidity Ratio} \quad \text{Quick ratio} &= \frac{\text{Cash} + \text{market. sec.} + \text{receivables}}{\text{Current liabilities}} \\ \text{Profitability Ratio} \quad \text{ROA} &= \frac{\text{Net income}}{\text{Total assets}} \\ \text{Profitability Ratio} \quad \text{ROE} &= \frac{\text{Net income}}{\text{Shareholder's equity}} \end{aligned}$$

**Discriminant Analysis**

$$\begin{aligned} Z &= (1.2x_1) + (1.4x_2) + (3.3x_3) + (0.66x_4) + (1.0x_5) \\ x_1 &= \frac{\text{Working capital}}{\text{Total assets}} \quad x_2 = \frac{\text{Retained earnings}}{\text{Total assets}} \quad x_3 = \frac{\text{EBIT}}{\text{Total assets}} \\ x_4 &= \frac{\text{Market value of equity}}{\text{Book value of debt}} \quad x_5 = \frac{\text{Sales}}{\text{Total assets}} \end{aligned}$$

**Logit Model**

$$\begin{aligned} F &= \frac{1}{1 + e^{-(13.7813 - 4.7252x_1 + 52.9741x_2 - 3.0594x_3 - 14.558x_4 + 0.1886x_5)}} \\ x_1 &= \frac{\text{Gross profit}}{\text{Total assets}} \quad x_2 = \frac{\text{Net income}}{\text{Total assets}} \quad x_3 = \frac{\text{Quick assets}}{\text{Current liabilities}} \\ x_4 &= \frac{\text{Total debt}}{\text{Total assets}} \quad x_5 = \frac{\text{Net worth}}{\text{Net fixed assets}} \end{aligned}$$

**Other Formulas**

$$\begin{aligned} \text{Working capital} &= \text{Current assets} - \text{Current liabilities} \\ \text{Total market value} &= \text{Year end stock price} \times \text{Shares outstanding} \end{aligned}$$

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# Incorporating ICT for Authentic Materials Application in English for Specific Purposes Classroom at Higher Education Institutions

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We are living in a world of advanced technology and most learners are exposed to ICT-based classrooms, where technology integration in the learning process serves as one of the hottest buzzwords in education all around the world. Nowadays, especially after the outbreak of COVID-19, technology integration has become not only a recommended, but also an inevitable way of running any academic process, including teaching English as a Foreign Language (EFL) and English for Specific Purposes (ESP). The presented article is an attempt to once more emphasise the importance of integrating technologies in teaching ESP at the level of tertiary education in Georgia for effective usage of authentic materials – TED talks, live stream, etc. – in the classroom, particularly while teaching ESP, and to prove its significance on the basis of the survey whose respondents were ESP specialists. A conclusion has been made that application of ICT in teaching/learning ESP is the most contemporary approach, which increases student motivation, engagement, autonomy, and language skills level. This happens due to the authentic nature of materials. The article recommends to increase the ICT use in ESP classes, to make it more various by materials and methods of teaching.

*Keywords:* information and communications technology (ICT), English for specific purposes (ESP), authentic materials, learner autonomy, engagement, language skills

## Introduction

Recently, educational technologies have become a part of our daily lives, especially after announcing the COVID-19 outbreak as a pandemic by the World Health Organisation on March 12, 2020 (World Health Organisation, 2020). This resulted in taking urgent measures, not only in the areas of primary vital importance, but also in the life of academia, revision, and

adaptation of English for specific purposes (ESP) courses, in order to meet the needs of online teaching. Compared to teaching general English (GE), teaching ESP has been relatively conservative, with a stress on terminology, its definitions, and translation. Consequently, ESP teaching before the shift of the whole educational systems to online regime applied ICT less than GE teaching.

The COVID-19 pandemic and the lockdown in spring 2020 resulted in obliging the instructors and learners to fully switch to an entirely ICT-based learning environment. In a globally shared new reality, EFL instructors started to share and exchange their approaches to the most effective online teaching platforms (Zoom, Cisco Webex, social media platforms, etc.), and did their best in order to timely respond to the challenge of all the mankind, i.e., succeeding in mandatory integration of technology in their learning process within the shortest ever terms.

As for the EFL teaching world, where technology has always, and especially since the 1960's, been present earlier than in any other academic field, integration of technology in ESP classrooms has mostly been present while demonstrating authentic materials, i.e. news, live recordings, TED talks and videos, this is indeed a normal language practice in continuous development-oriented countries, among them Georgia, where technology has been widely applied and integrated into EFL/ESP classroom, not only at higher educational institutions (HEIs), but also at secondary and primary educational institutions as well (Al-Kamel & Chouthaiwale, 2019; Basilaia & Kvavadze, 2020). A great number of teacher training programmes, international scientific and practical conferences, forums and workshops was organised by international (British Council, International House, IATEFL, etc.), as well as local organisations (e.g., ETAG – English Language Teachers' Association of Georgia). They were held both virtually and (where possible) on-site or in a hybrid regime, and have greatly contributed to introducing and practicing internationally recognised and approbated standards of ESP classrooms through an effective usage of technologies in real-life situations and daily encounters with our target audience at HEI in Georgia. However, some teacher training programmes seldom offered training on usage of ICT (to say nothing of teachers of elder generations who have not taken part in any ICT training programmes), which resulted in the failure of transition to online teaching and once again highlighted the necessity for training teachers in order to effectively incorporate ICT into their teaching both in a real and (inevitably) in an online classroom.

## **Literature Review**

### ***Authentic Materials in ESP and ICT***

Nunan and Millet (1995) define authentic materials as those which were not created for language learners. They illustrate how native speakers use

English naturally. Recently, authentic materials have become an invaluable resource for not only EFL, but also ESP classrooms. One of the words that have been creeping into English language teaching in the past few years is 'authentic.' It has a kind of magic ring to it: who, after all, would want to be 'inauthentic'?

The attribute 'authentic' may be applied to language and texts that come from real life instead of course-book writer-written educational texts. It may also be applied to activities which occur in everyday communication (instead of 'retell/translate the text' tasks and tests that are only used in the classroom) (Gilmore, 2007; Rogers & Medley, 1988). ESP teachers and students are naturally attracted to authentic materials, such as written texts and recorded videos, which have not been produced for the purpose of language learning, as well as oral materials, such as TED talks, recordings, shows, stand-up comedy programmes, emails, and blogs. The very finding that you are able to read something designed for a native speaker is motivating, as is developing strategies to deal with a 'real-life' situation in an effective way and to have a proper understanding of them. Also, authentic materials provide ESP learners with up-to-date information available in the field, as textbooks are unable to catch up with the changes due to the long writing, reviewing and publishing process.

Both teachers and students agree that authentic materials lead the class to real-life language usage and, in general, make ESP learning process more meaningful and engaging for the learners. The availability of a great variety of authentic materials through ICT is both challenging and beneficial for ESP teachers, since they need to pick the ones which would meet their learners' needs and expectations and, of course, then decide upon the form of integrating them into the ESP classroom. Meanwhile, authentic materials in technology-based ESP education indeed boost learner autonomy and a constructive learning process (Bielousova, 2017).

The authentic materials available through ICT (texts, video and listening materials) can offer much more variety (by topics, difficulty level and genres: field news, conference/journal papers, theses) than any book or even library. By using effective keywords, ESP students and teachers can find materials, appropriate for their needs and interests (Vaičiūnienė & Užpalienė, 2010).

### **ICT Application and Motivation in ESP**

English for Specific Purposes (ESP) is characterised on the one hand by a greater than GE functionality and corresponding instrumental motivation (Fiorito, 2006; González Ardeo, 2016; Hutchinson & Waters, 1987); on the other hand, it is usually written in a dry academic/professional language, packed with information mostly well known to the students and unemotional by nature, which sometimes leads students to boredom (Deveci, 2016).

One of the most challenging tasks faced in ESP education is how to boost learners interest on the searched topics through using authentic materials and thus motivate them for better learning of ESP (Zoocharian, 2015). In this regard, the materials derived from real-life experience should reflect a real language and finally contribute to an effective learning process. These materials may also contain little professional 'discoveries' for tertiary education students, as the new types of authentic materials available on the Internet contain a lot of novelties in the field of studies. ESP teachers indeed have a large amount of the materials available to be integrated into the classroom and to develop the most effective strategies for dealing with real language. Easily accessible websites, special interest groups (SIGs) and blogs can assist the learner to search for the most appropriate and up-to-date task-based materials applicable to their field of knowledge (Torregrosa Benavent & Sánchez-Reyes Peñamaría, 2011).

An Internet search provides teachers with unlimited resources in the frame of profession-based and specific topics. Hence, online interactions between ESP teachers and learners (e.g., teacher searching for sites on specific themes, making up questions, preparing online posts for students, etc.) can successfully replace printed authentic materials such as newspaper articles, brochures, conference abstracts and proceedings brought into the classroom to make it livelier. ICT serves as the most effective means for getting familiar with computer-based information (e.g. TV and radio interviews, the news, video clips, advertising, TV copies on YouTube, podcasts, TEDx talks, broadcasts, etc.). The Internet nowadays serves as the most frequently and constantly updated source of information, being visually more stimulating and interactive. Hence, the above-mentioned authentic materials keep students abreast about recent developments in the world, having which serves an educational function.

### ***ICT and ESP Communication***

Out of the above-listed great variety of authentic materials, while considering the most effective ways of their integration into the ESP classroom, technologies have always represented one of the most commonly used forms. Technology has always played a crucial role in ESP education due to two different reasons. Primarily, ICT serves as a tool assisting in the traditional form of foreign language acquisition and secondly, it represents a means for establishing new forms of communication and connection with the learners. All fields of ESP education, being basically based on meeting the specific needs of the learners related to their major specialty, have actually been influenced by the ongoing developments existing in the field of technology. ICT has been actively used in ESP classes in order to create the context for communication with oral, literate, and visual models of the discourse.

This includes synchronous forms of discourse, e.g., chatting (an interaction between the participants within the same time frame), asynchronous forms of the discourse (emails, blogs, forums, networking sites like Facebook and LinkedIn, etc.). But the problems remain in choosing the most effective and needs-oriented types of technologies in order to positively affect the achievement of the goals set for the particular ESP classroom. Hence, the decision about the right choice of technologies can be linked to more conventional decisions taken towards the aims and objectives set within the curriculum. While selecting the aims and objectives of the curriculum, ESP teachers have always depended on assessing learners' particular needs and constraints. Hyland also argued about the beginning of the ESP curriculum with an immediate assessment of the learners' needs (Hyland, 2002).

### ***ICT and Application of Tasks in ESP Teaching***

Córdoba Cubillo and Navas Brenes (2009) describe how task-based teaching can be applied via ICT while teaching ESP, which include pre-task, while-task and post-task stages. Pre-task can be done by the teacher (search of materials online), while-task can be done on social nets by students in pairs and group, and post-task can be fulfilled online on such platforms as Zoom, Google Meet, Teams, etc.

### ***ICT and Developing Language Skills***

Technologies can be applied across all types of ESP classrooms. However, each technology has, to a certain extent, created its own norms and values for language usage, from which some had also influenced language usage in face-to-face circumstances. Hence, being aware of the character of this language is of utmost importance for ESP teachers, who should engage their students in these types of technologies responding to their needs of using English, often called as Lingua Franca under ICT-based circumstances. The choice of particular ICT to be used requires making a comparison between the types of relationships one is engaged in, and the character of the language. As technologies have become an inevitable part of ESP education, serving as an instrument for language acquisition, a place for obtaining different authentic materials and also a platform for publishing and sharing work, its impact and importance have been even more complex and controversial together with all above-listed factors (Bajcsy, 2002; Warschauer & Meskill, 2000). All language skills (listening, speaking, reading, and writing) can be developed via ICT. While it is quite obvious that listening and reading skills can be developed through ICT application, as there are abundant authentic listening and reading materials on the Internet (the tasks based on them may be developed both by teachers and student) (Filiçkaya,

2018; Roig-Vila & Santiago, 2014), the development of speaking and writing skills is less obvious. Kuppuraj (2017) states that speaking skills based on listening and reading materials from the Internet are more motivating for EFL learners, especially if they have chosen the materials. Besides, ESP students can orally communicate via Facebook voice Messenger, Whatsapp and other platforms which enable oral communication (the communication can be with both specialty teachers and group-mates, and with international members of relevant special interest groups). Analogously, writing skills can be improved by applying e-mail and messenger for written communication with specialty teachers and group-mates and with international members of relevant special interest groups.

### **ICT and Learner Autonomy in ESP Teaching**

Radosavlevikj & Hajrullai (2019) mention that Learner Management Systems (LMS) help improve the learning process and make it quite autonomous. These systems enable students to plan their learning, carry it out and perform self-assessment. Students can also improve the quality of teaching by being engaged in curriculum, course, and lecturer assessment.

Therefore, ICT application is indispensable in education in extreme situations, such as a pandemic. In a normal situation it also offers a great number of advantages. To teach ESP in a motivating way is easier with ICT, as it is various and up-to-date, enables taking student preferences into consideration, permits in-class and out-of-class learning, provides authentic materials, encourages learner autonomy, supports task-based teaching. Concerning language learning *per se* and the development of communicate skills, ICT also creates better conditions of ESP learning and teaching.

### **Research Method**

For the purposes of objectivity of results, quantitative research method was applied. A small-scale survey research (the applied tool – a questionnaire developed by the researchers based on the literature analysis) was held. The questionnaire format was a 5-point Likert scale – from 1 – completely disagree to 5 – completely agree. The reliability of the questionnaire was assessed by 30 university teachers of ESP (i.e., a group, analogous to the further research participants), not taking part in the research itself by test-retest procedure. They were English teachers of English, members of Special Interest Groups of ESP at the IATEFL. They were given the questionnaire twice, with a short (a couple of minutes) break, to see the consistency of their answers. Initially there were 8 items, however, finally 6 were left, as the other two were either synonymous or antonymous to the given items, in order to see whether the assessments were given meaningfully and not mechanically. Due to this piloting it became possible to see that the re-



**Table 1** Defining the Reliability of the Questionnaire (Cronbach's Alpha)

Item	(1)	(2)
1. ICT application for ESP education has become one of the major issues of contemporary EFL education.	3.80	3.81
2. The use of technology plays a crucial role in increasing student motivation for ESP teaching/learning through presenting authentic materials.	4.01	4.01
3. Technology undertakes a significant function of the authentic materials in ESP classroom.	4.12	4.10
4. ICT tools are the most effective means to encourage ESP learners to become more autonomous and responsible for their own learning.	3.75	3.78
5 (and 5a; synonymous). Web-based learning environment in ESP classroom has a great potential to support student application of task-based authentic materials (e.g., TED-talks, broadcasts) and to enhance their learning outcomes	4.00	4.20
6 and 6a (antonymous). ICT plays a key role in developing language skills and promoting different types of interaction that enhance learning, and, in turn, lead to increased student motivation in the subject matter and ESP language proficiency and outside world through presenting authentic materials in ESP classroom.	3.87	3.87

**Notes** Column headings are as follows: (1) variable 1: first mean results, (2) variable 2: second mean results. Cronbach's alpha = 0.926.

spondents clearly understand the suggested items. Table 1 below shows the obtained results.

The calculations were done with SPSS-24 software. They demonstrated that Cronbach's alpha of the two variables (two measurements done with the Likert scale) equals 0.926 or the correlation between the results of both measurements is very high (close to 1). This means that the questionnaire is reliable and can be used in this and other researches. As for the content validity of the questionnaire, it was assessed by three international experts in the field and, as result, a minor modification of formulation of items took place.

The link to the questionnaire was uploaded to social networks for a month. Therefore, convenience sampling was applied, due to the time limitations of the research. Thus, the results cannot be generalised, and they only reveal a certain trend. However, as they are in agreement with other researches (see discussion), their publication does add to understanding of the general situation in ESP teaching via ICT application. The respondents were mostly university ESP teachers from Georgia, however, 35% of the respondents were from several European and Asian countries.

Table 2 presents the statistical results of the questionnaire application: measures of central tendency (mean, mode, and median) and of variability (standard deviation, skewness, and kurtosis). Item numbers are the same

**Table 2** Descriptive Statistics

Item	(1)	(2)	(3)	(4)	(5)	(6)
1	3.9250	5.0	4.0	0.99711	-0.497	-0.818
2	3.9600	4.0	4.0	0.92494	-1.208	1.674
3	4.2000	4.0	4.0	0.80812	-1.353	2.277
4	3.8750	5.0	4.0	1.06669	-0.540	-0.919
5	4.3000	5.0	5.0	1.28502	-1.818	2.157
6	3.9565	5.0	4.0	1.29883	0.350	0.382

**Notes** Column headings are as follows: (1) mean, (2) mode, (3) median, (4) standard deviation, (5) skewness, (6) kurtosis.

**Table 3** One-Sample Statistics

N	Mean	Standard deviation	Standard error mean
6	4.03	0.1714236	0.699834

as in the Table 1). All calculations, in Tables 1 and 2, were made with the statistical program SPSS 22. The mean results reveal that all answers are positive (close to or more than 4 on a 5-point Likert scale). As modes and medians are rather similar to mean results (4–5), we can view the results as trustworthy. However, the standard deviation, from 0.81 to 1.29 reveals that the opinions differ among the respondents (the group is reasonably heterogeneous, from the point of view of their viewpoints). The negative skewness in assessments of items 1–5 reveals that more respondents have lower assessments than the mean result compared to the number of the respondents who gave higher answers. On the other hand, the low but positive skewness of the last item (0.35) demonstrates that more respondents assessed the item more positively than the mean result shows (compared to those who gave it a low assessment). As on the whole the means are quite high, this does not change the overall picture too much.

Interestingly, the results of piloting of the questionnaire (with means between 3.80 and 4.20), in fact, are quite similar to the results of the survey. They also support the usefulness of ICT application while teaching ESP due to the authenticity of the materials.

We also held a one-sample *T*-test, to see whether the assessments of various features of ICT application in ESP teaching (most contemporary approach, increasing motivation, providing authentic materials and task-based activities, and effective interaction) differ significantly from each other. Tables 3 and 4 presents these results.

It is possible to see that  $p = 0.000 < 0.05$ , therefore, the obtained results are significantly different (for instance, the 3rd item: technology undertakes a significant function of the authentic materials in ESP classroom, and the 6th item: ICT plays a key role in developing language skills and pro-

**Table 4** One-Sample T-test

t	DF	Significance, 2-tailed	Mean difference	95% confidence interval of the difference	
				Lower	Upper
57.672	5	0.000	4.0360833	3.8561185	4.215981

**Table 5** Detailed Questionnaire Results

Survey Question	(1)	(2)	(3)	(4)	(5)
ICT application for ESP education in Georgia, as elsewhere, has become one of the major trends of contem. English language teaching in higher education institutions	0.0	10.0	22.5	32.0	32.5
The use of technology, according to the respondent teachers, increased student motivation for ESP teaching/learning by presenting authentic materials	2.5	5.0	5.0	55.0	32.5
Technology naturally integrates authentic materials in ESP classrooms	0.0	5.0	7.5	55.0	32.5
ICT tools are the most effective means to enable ESP learners to become more autonomous learners	0.0	18.8	18.8	37.5	25.0
The web-based learning environment in the ESP classroom has a great potential to support students' performance of tasks-based authentic materials (e.g., Ted talks and broadcasts) and to enhance their learning outcomes	0.0	2.5	5.0	35.0	57.5
ICT plays a key role in developing language skills and promoting different types of interaction that enhance learning and in developing ESP language proficiency	0.0	12.5	12.5	43.8	31.3

**Notes** Column headings are as follows: (1) completely disagree, (2) disagree, (3) do not have a clear opinion, (4) agree, (5) completely agree. In percent.

moting different types of interaction that enhance learning) were assessed especially high, while the 4th item (ICT tools are the most effective means to encourage ESP learners to become more autonomous) got a relatively low assessment.

### Discussion

This paper contributes to the topic of incorporating ICT for authentic materials application in English for specific purposes classroom at higher education institutions (mostly in in Georgia).

The survey held has revealed that the respondent teachers support using ICT for ESP teaching. They agree that it is not simply the most contemporary trend (means 3.80/3.81/3.92), but also motivates students through the

use of authentic materials (means 4.01/3.96/4.12/4.10/4.20). ICT-based materials applied in ESP teaching support the development of learner autonomy (means 3.75/3.78/3.875). ICT application creates a learning environment that enables to apply task-based learning (means 4.00/4.20/4.30). Using technologies supports the development of language skills due to providing good samples of interaction and stimulating discussion around the contents of the materials (means 3.87/3.957).

Irrespective of the general agreement on the idea that information communication technologies are beneficial in a variety of areas of higher education (Fifeková, Nežinský, & Valachová, 2019; Mesaric, Kovacevic, & Šebalj, 2017; Omona, van der Weide, & Lubega, 2010; Spieler & Kovac, 2017), including English language teaching (Al-Kamel & Chouthaiwale, 2018, Sabiri, 2019; Tri & Nguen, 2014), there are few empirical studies on their application for English for Specific Purposes teaching, while the majority of the publications dealing with the issue are narrative/descriptive (Torregrosa Benavent & Sánchez-Reyes Peñamaría, 2011; Zoolarian, 2015). However, we found some empirical researches the findings of which are all in agreement with our findings. Brinton (2001), for instance, mentions that 'they [ICT] can reinforce for the students the direct relation between the language classroom and the outside world' (p. 461). Besides this, when they are presented through the usage of technology, e.g. TED talks, news reports, Youtube videos, etc. ESP learners mostly focus on understanding the content rather than the form. Thus, presenting such materials through ICT represents a rather valuable means for effective language input and boosts the learners' self-esteem and desire to take more serious and advanced steps to ESP acquisition, among the learners.

Vaičiūnienė and Užpalienė (2010) held a survey on 122 students' views on motivation of learning ESP. The respondents supported the benefits offered by technology-based authentic materials: 'educational and communicative value, development of professional knowledge, valuable source of language input' (p. 94). Ayuningtyas (2017) held an observation with a questionnaire including 117 university technical students learning business English, which also confirmed that students both benefit from and enjoy using authentic materials, especially those found on the Internet. Nadrag and Buzarna-Tihinea (2017) emphasise the increase of student communicative competence through the use of authentic materials in ESP classes.

The first finding of the submitted research is that ICT has become indispensable for ESP teaching (the mean result is 3.92 on a 5-point Likert scale, which is a high enough result. The finding partially coincides with previous studies on similar topics. Although Simonova (2014) expected that the application of ICT for ESP teaching would yield higher academic achievement, it did not occur in her 2-year study with 303 faculty of informatics and

management students in Croatia. However, she states the low level of technology skills of language teachers among the possible reasons of such results. Donal et al. (2020) in their study including 52 agro-business students revealed that the respondents (students) apply ICT in ESP for several purposes: as materials resources, unlimited professional communication means and for classroom management (when students are split into groups working together in class and/at home to complete an ESP task).

According to the second finding, the use of technology is crucial for motivation while teaching/learning ESP (mean result 3.96). Altalib (2019) came to a similar finding. Based on Dörnyei's (2005, 2009) second language motivational self-System, he delivered ESP and general English classes to 4,043 students at four Saudi universities. The students then filled in an online survey which revealed that the ESP group increased motivation more than the GE group.

The third finding has demonstrated that nowadays ICT has the major role in providing up-to-date authentic materials for ESP students (mean result 4.2), as the majority of existing ESP textbooks contain mostly outdated and often adapted authentic or totally inauthentic texts. This finding is in line with Blagojević (2013) and Pérez Cañado and Esteban (2015).

The finding that ICT tools increase ESP learner autonomy (mean result is 3.875) is supported by Selama (2018) and Diaz Ramirez (2014). Selama (2018) held a case study in Algeria for 40 English for Engineering students. In a survey, they confirmed that the application of ICT has contributed a lot to their autonomy as language learners. An action research was conducted by Diaz Ramirez at a public university in Colombia with environmental engineering undergraduates. Through students' field notes, semi-structured interviews, self-assessment questionnaires and video recordings, the researcher came to the conclusion that their learner autonomy was gradually increasing and eventually reached a high level.

The fifth finding emphasised that the ICT-based learning environment permits to involve the students into task-based activities (mean result 4.3). This finding is in line with the research by Yundayani et al. (2019).

And, finally, the finding that ICT plays a key role in developing language skills and promoting different types of interaction that enhance learning (mean result equals 3.9565) is in line with numerous other studies (Al-Kamel & Chouthaiwale, 2018; Brinton, 2001; Dörnyei, 2009, 2005).

The results of different questions are significantly different from each other ( $p = 0.000 < 0.05$ , according to one-sample *T*-test (Cronbach's alpha).

## Conclusion

To once again prove the importance of ICT in effective integration of authentic materials in ESP classrooms, a small-scale online survey was conducted

in Georgia among ESP teachers. The findings were as follows and the majority of the participant teachers completely agreed or agreed that:

1. ICT application for ESP education in Georgia, as elsewhere, has become one of the major trends of contemporary English language teaching in higher education institutions.
2. The use of technology, according to the respondent teachers, increased student motivation for ESP teaching/learning by presenting authentic materials.
3. Technology naturally integrates authentic materials in ESP classrooms.
4. ICT tools are the most effective means to enable ESP learners to become more autonomous learners.
5. The web-based learning environment in the ESP classroom has a great potential to support student performance of tasks-based authentic materials (e.g., Ted talks and broadcasts) and to enhance their learning outcomes.
6. ICT plays a key role in developing language skills and promoting different types of interaction that enhance learning and in developing ESP language proficiency.

These results are in line with other researches on the issue, according to which, ICT enables ESP teachers to incorporate fresh authentic materials according to student interests and needs in the ESP classrooms. This enhances the application of communicative approach to language learning, motivates learners through visual images/recordings, broadcasts taken from real-life situations and engages them in most interesting discussions and debates around the specific professional areas. Students and teacher search for authentic materials on the Internet, fulfil written or oral assignments, and eventually submitting what they have done for assessment.

### Recommendations

As this research was limited in scale and generally, there is a certain lack of empirical studies dealing with application of EST in teaching/learning ESP and a further, wider-scale research on the issue is necessary. But even the limited number of such studies enables us to recommend to increase the ICT use in ESP classes, to make it more various by materials and methods of teaching.

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# On Some Applications of Matrix Partial Orders in Statistics

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In statistics different partial orders appear as useful in several cases. Three of the best known partial orders defined on (sub)sets of real or complex matrices are the Löwner, the minus and the star partial orders. Another two matrix partial orders that are related to the star partial order are the left-star and the right-star partial orders. In the paper we review some of the applications of mentioned partial orders in statistics.

*Keywords:* matrix partial order, generalized matrix inverse, preserver, statistics, linear model

## Introduction

Mathematics is essential for all (serious) branches of science, including natural science, engineering, medicine, finance, and in the last few decades also for social sciences. One can argue that a particular practice becomes a scientific discipline when it starts to obey the postulates of mathematics and adopts the mathematical language and mathematical (especially analytical) way of thinking. Mathematics and statistics are becoming increasingly important in daily operations of various organizations, e.g. for modern knowledge management (i.e. a process of creating, sharing, using and managing the knowledge and information of an organization) the use of mathematics and statistics is crucial (Munje et al., 2020; Phusavat et al., 2009; Priestley & McGrath, 2019). Linear algebra is a branch of mathematics that especially in its subbranch of matrix theory encompasses results which are used in various fields of science and practice. We can not imagine modern (micro and macro) economics and econometrics without the use of matrices. Matrices are for example useful in observing the relationships between individual industries and in calculating the quantities needed to meet the demand for goods produced in the industries of an economy. We can also use matrices in linear programming in management to for example adjust production processes by solving optimization problems such as calculation of the minimum of production costs. In the paper we present particular relations between matrices that have many applications in statistics and

thus in other scientific fields, and give an overview of these applications.

Let  $\mathbb{F}$  denote the field of all real or complex numbers, i.e.  $\mathbb{F} = \mathbb{R}$  or  $\mathbb{F} = \mathbb{C}$ , and  $M_{m,n}(\mathbb{F})$ , the set of all  $m \times n$  matrices over  $\mathbb{F}$ . If  $m = n$ , then we write  $M_n(\mathbb{F})$  instead of  $M_{n,n}(\mathbb{F})$ . Let  $A^* \in M_{n,m}(\mathbb{F})$  denote the conjugate transpose of  $A \in M_{m,n}(\mathbb{F})$  (if  $A \in M_{m,n}(\mathbb{R})$ , then  $A^* = A^t$ , the transpose of  $A$ ). A generalized inverse or a pseudoinverse of  $A \in M_{m,n}(\mathbb{F})$  is a matrix that has some properties of the usual inverse (of  $A \in M_n(\mathbb{F})$  with the nonzero determinant) but not necessarily all of them. One of the best known examples of a generalized inverses is the Moore-Penrose inverse. We say that  $X \in M_{n,m}(\mathbb{F})$  is the *Moore-Penrose inverse* of  $A \in M_{m,n}(\mathbb{F})$  when the following four matrix equations are satisfied:

$$AXA = A, \quad XAX = X, \quad (AX)^* = AX, \quad \text{and} \quad (XA)^* = XA. \quad (1)$$

It turns out (Mitra et al., 2010) that every  $A \in M_{m,n}(\mathbb{F})$  has a Moore-Penrose inverse  $X = A^\dagger$  and that  $A^\dagger$  is unique. Another example of a pseudoinverse satisfies only the first equation in (1). Namely, we say that  $X = A^-$  is an *inner generalized inverse* of  $A \in M_{m,n}(\mathbb{F})$  if  $A = AA^-A$ . Again, every  $A \in M_{m,n}(\mathbb{F})$  has an inner generalized inverse  $A^-$  however  $A^-$  is not necessarily unique. There are many applications of these pseudoinverses. For example, if  $A \in M_{m,n}(\mathbb{F})$ ,  $c \in M_{m,1}(\mathbb{F}) = \mathbb{F}^m$ , and  $x$  is the  $n \times 1$  vector of variables, then the system

$$Ax = c \quad (2)$$

of  $m$  linear equations with  $n$  variables has a solution if and only if  $AA^-c = c$  for some inner generalized inverse  $A^-$  of  $A$ . Moreover, if the system (2) has a solution and if  $A^-$  is an inner generalized inverse of  $A$ , then for every vector  $y \in \mathbb{F}^n$

$$x_y = A^-c + (I - A^-A)y, \quad (3)$$

where  $I \in M_n(\mathbb{F})$  is the identity matrix, is a solution of (2), and for every solution  $x_*$  of (2) there exists a vector  $y$  such that  $x_* = x_y$  (Schott, 2005).

Both of the above classes of generalized inverses induce partial orders on  $M_{m,n}(\mathbb{F})$  (i.e. relations that are reflexive, antisymmetric, and transitive). We say that  $A \in M_{m,n}(\mathbb{F})$  is dominated by (or is below)  $B \in M_{m,n}(\mathbb{F})$  with respect to the *minus partial order* and write

$$A \leq^- B \quad \text{when} \quad A^-A = A^-B \quad \text{and} \quad AA^- = BA^- \quad (4)$$

for some inner generalized inverse  $A^-$  of  $A$ .

For  $A, B \in M_{m,n}(\mathbb{F})$  we write

$$A \leq^* B \quad \text{when} \quad A^*A = A^*B \quad \text{and} \quad AA^* = BA^* \quad (5)$$

and name the relation  $\leq^*$  the star partial order. It turns out that both relations (4) and (5) are indeed partial orders (Drazin, 1978; Hartwig, 1980). Moreover, the star partial order may also be defined by a generalized inverse. Namely, it is easy to see that for  $A, B \in M_{m,n}(\mathbb{F})$  we have

$$A \leq^* B \text{ if and only if } A^\dagger A = A^\dagger B \text{ and } AA^\dagger = BA^\dagger$$

where  $A^\dagger$  is the Moore-Penrose inverse of  $A$ .

Two partial orders that are ‘related’ to the minus and the star partial orders are the left-star and the right-star partial orders (Baksalary & Mitra, 1991). Let  $\text{Im}A$  denote the image (i.e. the column space) of  $A \in M_{m,n}(\mathbb{F})$ . For  $A, B \in M_{m,n}(\mathbb{F})$  we say that  $A$  is dominated by  $B$  with respect to the left-star partial order and write

$$A \preceq B \text{ when } A^*A = A^*B \text{ and } \text{Im}A \subseteq \text{Im}B. \tag{6}$$

Similarly, we define the right-star partial order: For  $A, B \in M_n(\mathbb{F})$  we write

$$A \preceq^* B \text{ when } AA^* = AB^* \text{ and } \text{Im}A^* \subseteq \text{Im}B^*. \tag{7}$$

It is known (Mitra et al., 2010) that for  $A, B \in M_{m,n}(\mathbb{F})$ ,  $A \leq^* B$  implies both  $A \preceq B$  and  $A \preceq^* B$  and each  $A \preceq B$  and  $A \preceq^* B$  implies  $A \leq^- B$ . The converse implications do not hold in general.

Another well known partial order may be defined on a certain subset of  $M_n(\mathbb{F})$ . We say that  $A \in M_n(\mathbb{F})$  is Hermitian (or symmetric when  $A \in M_n(\mathbb{R})$ ) if  $A = A^*$ . A Hermitian matrix  $A \in M_n(\mathbb{F})$  is said to be positive semidefinite if  $x^*Ax \geq 0$  for every  $x \in \mathbb{F}^n$ . Positive semidefinite matrices have become fundamental computational objects in many areas of statistics, engineering, quantum information, and applied mathematics. They appear as variance-covariance matrices in statistics, as elements of the search space in convex and semidefinite programming, as kernels in machine learning, as density matrices in quantum information, and as diffusion tensors in medical imaging. It is known (Christensen, 1996) that every variance-covariance matrix is positive semidefinite, and that every real positive semidefinite matrix is a variance-covariance matrix of some multivariate distribution. Let now  $A, B \in M_n(\mathbb{F})$  be Hermitian matrices. We say that  $A$  is dominated by  $B$  with respect to the Löwner partial order and write

$$A \leq^L B \text{ if } B - A \text{ is positive semidefinite.} \tag{8}$$

There are many applications of the above partial orders, especially in statistics. Let us present an example of such an application (Mitra et al., 2010). Let  $A, B \in M_n(\mathbb{R})$  be two positive semidefinite matrices and let  $A \leq^L B$ . Write

$$A = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \text{ and } B = \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix}$$

where  $A_{ij}$  and  $B_{ij}$  are of the same order for all  $i, j \in \{1, 2\}$  and  $A_{11}$  is a  $r \times r$ ,  $r < n$ , matrix. Then (Sengupta & Jammalamadaka, 2003)

$$A_{11} - A_{12}A_{22}^{-1}A_{21} \leq^L B_{11} - B_{12}B_{22}^{-1}B_{21}. \tag{9}$$

Consider now a tribal population on which several anthropometric measurements are made. Let  $y_1$  be the vector of measurements on the face and  $y_2$  the vector of measurements on the remaining part of the body. Let the random vector  $y = \begin{bmatrix} y_1 \\ y_2 \end{bmatrix}^t$  have the multivariate normal distributions  $N(\mu, V_1)$  in population 1 and  $N(\tau, V_2)$  in population 2. Here  $\mu$  and  $\tau$  are the mean vectors and  $V_1$  and  $V_2$  are the variance-covariance matrices (also known as dispersion or covariance matrices). Suppose  $y$  has a smaller dispersion in population 1 than in population 2. The ‘smaller dispersion’ condition may be expressed in terms of the Löwner partial order  $\leq^L$ , i.e.  $V_1 \leq^L V_2$ . By (9) and by properties of variance-covariance (dispersion) matrices (Sengupta & Jammalamadaka, 2003, p. 59) we have the following: The conditional dispersion of facial measurements given the measurements of the rest of the body, namely  $V(y_1 | y_2)$ , is also smaller in population 1 than in population 2.

In the following two sections more applications of the above partial orders in statistics will be presented – we will focus our attention on linear models. In the next section (Linear Models) we will recall the notion of a linear model and then use matrix partial orders to compare different linear models. In the last decades many authors studied *preserver problems* which concern the question of determining or describing the general form of all transformations of a given structure  $\mathcal{X}$  which preserve a quantity attached to the elements of  $\mathcal{X}$ , or a distinguished set of elements of  $\mathcal{X}$ , or a given relation among the elements of  $\mathcal{X}$ , etc. It has been recently stated (Dolinar et al., 2020; Golubić & Marovt, in press, 2020; Guillot et al., 2015) that a motivation for the study of preserver problems that concern the above partial orders on certain (sub)sets of real matrices (i.e.  $\mathcal{X}$  is a subset of  $M_n(\mathbb{R})$ ) comes from statistics. Let  $\mathcal{S}$  be a subset of  $M_n(\mathbb{F})$  and let  $\leq_G$  be one of the above orders (i.e.  $\leq^-, \leq^*, \leq^{\otimes}, \leq^{\oplus}, \leq^L$ ) on  $\mathcal{S}$ . We say that the map  $\Phi: \mathcal{S} \rightarrow \mathcal{S}$  preserves the partial order  $\leq_G$  in both directions (or is a bi-preserver of  $\leq_G$ ) when for every  $A, B \in \mathcal{S}$ ,

$$A \leq_G B \quad \text{if and only if} \quad \Phi(A) \leq_G \Phi(B). \tag{10}$$

In the last section (Preservers of Partial Orders) we will recall some recent results that were motivated by statistics and that (under some additional assumptions) describe the form of maps  $\Phi$  with the property (10).

### Linear Models

One of the simplest models that is used to illustrate how an observed quantity  $y$  can be explained by a number of other quantities,  $x_1, x_2, \dots, x_{p-1}$ , is the linear model

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_{p-1} x_{p-1} + \epsilon,$$

where  $\beta_0, \beta_1, \dots, \beta_{p-1}$  are constants (real numbers) and  $\epsilon$  is an error term that accounts for uncertainties. We refer to  $y$  as a *response variable* and to  $x_1, x_2, \dots, x_{p-1}$  as *explanatory variables*. For a set of  $n$  observations of the response and explanatory variables, the explicit form of the equations would be

$$y_i = \beta_0 + \beta_1 x_{i,1} + \beta_2 x_{i,2} + \dots + \beta_{p-1} x_{i,p-1} + \epsilon_i, \quad i = 1, 2, \dots, n,$$

where for each  $i$ ,  $y_i$  is the  $i$ -th observation of the response,  $x_{i,j}$  is the  $i$ -th observation of the  $j$ -th explanatory variable ( $j = 1, 2, \dots, p - 1$ ), and  $\epsilon_i$  is the unobservable error corresponding to this observation. These equations can be written in the following matrix form:

$$y = X\beta + \epsilon.$$

Here,

$$y = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix}, \quad X = \begin{bmatrix} 1 & x_{1,1} & \dots & x_{1,p-1} \\ 1 & x_{2,1} & \dots & x_{2,p-1} \\ \vdots & \vdots & \ddots & \vdots \\ 1 & x_{n,1} & \dots & x_{n,p-1} \end{bmatrix}, \quad \beta = \begin{bmatrix} \beta_0 \\ \beta_1 \\ \vdots \\ \beta_{p-1} \end{bmatrix}, \quad \epsilon = \begin{bmatrix} \epsilon_1 \\ \epsilon_2 \\ \vdots \\ \epsilon_n \end{bmatrix}.$$

We call  $y$  the *response vector* (also known as *the observation vector*) and  $X$  the *model matrix* (also known as *the design or regressor matrix*). In order to complete the description of the model, some assumptions about the nature of the errors have to be made. It is assumed that  $E(\epsilon) = 0$  and  $V(\epsilon) = \sigma^2 D$ , i.e. the errors have the zero mean and covariances are known up to a scalar (real number). Here  $V$  denotes the variance-covariance matrix. The nonnegative parameter  $\sigma^2$  and the vector of parameters (real numbers)  $\beta$  are unspecified, and  $D$  is a known  $n \times n$  (real, positive semidefinite) matrix. We denote this linear model with the triplet  $(y, X\beta, \sigma^2 D)$ . (It follows that  $E(y) = X\beta$  and  $V(y) = \sigma^2 D$ .) It is known (Mitra et al., 2010, Lemma 15.2.1) that the response vector  $y \in \text{Im}(X:D)$  with probability 1 where  $\text{Im}(X:D)$  denotes the image (i.e. the column space) of the partitioned matrix  $(X:D)$ .

**Remark** An assumption that the errors follow the multivariate normal distribution is often added to the model. Moreover, the matrix  $X$  above where all the elements in a first column equal 1 is in fact a special case of a linear model matrix; such model matrices are used in the multiple regression analysis. Models  $(y, X\beta, \sigma^2 D)$  where all the elements in the first column of the model matrix do not necessarily equal 1 and the probability distribution of the errors is not necessarily normal are (usually) called general linear

models. In the continuation we will deal with general linear models, however, for the sake of simplicity we will use the term “linear model” instead of “general linear model”.

Classical inference problems related to the linear model  $(y, X\beta, \sigma^2D)$  usually concern a linear parametric function (LPF),  $s\beta$  (here  $s$  is a  $1 \times p$  real vector). We try to estimate it by a linear function of the response  $zy$  (here  $z$  is a  $1 \times n$  real vector). For accurate estimation of  $s\beta$ , it is desirable that the estimator is not systematically away from the ‘true’ value of the parameter. We say that the statistic  $zy$  is a *linear unbiased estimator* (LUE) of  $s\beta$  if  $E(zy) = s\beta$  for all possible values of  $\beta$ . A LPF is said to be estimable if it has an LUE.

Let  $(y, X\beta, \sigma^2D)$  be a linear model and let  $A$  be a real matrix with  $p$  columns. We say that a vector LPF,  $A\beta$ , is *estimable* if there exists a real matrix  $C$  such that  $E(Cy) = A\beta$  for all  $\beta \in \mathbb{R}^p$ . It turns out (Mitra et al., 2010, Theorem 15.2.4) that if  $A$  is a real matrix with  $p$  columns, then

$$A\beta \text{ is estimable if and only if } \text{Im}A^t \subseteq \text{Im}X^t. \tag{11}$$

The *best linear unbiased estimator* (BLUE) of an estimable vector LPF is defined as the LUE having the smallest variance-covariance matrix. Here, the “variance-covariance” condition is expressed in terms of the Löwner order  $\leq^L$ : Let  $A\beta$  be estimable. Then  $Ly$  is said to be BLUE of  $A\beta$  if (i)  $E(Ly) = A\beta$  for all  $\beta \in \mathbb{R}^p$  and (ii)  $V(Ly) \leq^L V(My)$  for all  $\beta \in \mathbb{R}^p$  and all  $My$  satisfying  $E(My) = A\beta$ .

Let us consider two linear models  $L_1 = (y_1, X_1\beta, \sigma^2D_1)$  and  $L_2 = (y_2, X_2\beta, \sigma^2D_2)$  where the number  $p$  of columns of  $X_1$  and  $X_2$  is fixed but arbitrary while the number  $n$  of rows may vary from model to model. Then we say that  $L_1$  is *at least as good as*  $L_2$  if for any LUE,  $a_2y_2$ , of a parameter  $k\beta$  there exists LUE  $a_1y_1$  of this parameter such that  $V(a_1y_1) \leq V(a_2y_2)$  (here  $a_1, a_2, k$  are appropriate vectors, and  $V$  denotes the variance). If this condition is satisfied, then we write

$$L_1 \geq L_2.$$

With the following result, which was proved in Stępniać (1985), Stępniać showed that two linear models  $L_1$  and  $L_2$  may be compared by considering certain matrices that are induced by matrices  $X_i$  and  $D_i, i \in \{1, 2\}$ , and comparing them via the Löwner partial order.

**Theorem 1** *Let  $L_1 = (y_1, X_1\beta, \sigma^2D_1)$  and  $L_2 = (y_2, X_2\beta, \sigma^2D_2)$  be two linear models. Then  $L_1 \geq L_2$  is equivalent to  $M_2 \leq^L M_1$  where  $M_i, i \in \{1, 2\}$ , are positive semidefinite matrices defined as*

$$M_i = X_i^t(D_i + X_iX_i^t)^-X_i.$$



Here  $(D_i + X_i X_i^t)^-$  is an inner generalized inverse of  $D_i + X_i X_i^t$ .

With the next two results (Mitra et al., 2010, Theorems 15.3.6, 15.3.7) we consider the linear models with model matrices that are related to each other under the minus partial order or the left-star partial order. Let  $L_1 = (y, X_1 \theta, \sigma^2 D)$  and  $L_2 = (y, X_2 \beta, \sigma^2 D)$  be two linear models and suppose  $X_1 \leq^- X_2$ . Note that for any two matrices  $A, B \in M_{m,n}(\mathbb{F})$ , we have  $A \leq^- B$  if and only if  $B - A \leq^- B$  (Mitra et al., 2010, Theorem 3.3.16). Let  $A = X_2 - X_1$ . It follows that then  $A \leq^- X_2$  and therefore by (4) there exists an inner generalized inverse  $A^-$  of  $A$  such that  $A^- A = A^- X_2$  and  $AA^- = X_2 A^-$ . Since then  $A = AA^- A = AA^- X_2$  and thus  $A^t = X_2^t (AA^-)^t$ , we may conclude that  $\text{Im} A^t \subseteq \text{Im} X_2^t$  (i.e.  $A\beta$  is by (11) estimable in the model  $L_2$ ). Let the model  $L_2$  be constrained by linear constraints  $A\beta = 0$  on the parametric vector  $\beta \in \mathbb{R}^p$ . Observe that on the one hand  $A = X_2 - X_1$  and  $AA^- = X_2 A^-$  imply

$$X_1 = X_2 - A = X_2 - AA^- A = X_2 - X_2 A^- A = X_2(I - A^- A), \tag{12}$$

and on the other hand,  $(I - A^- A)\theta$  where  $\theta \in \mathbb{R}^p$  is arbitrary are by (3) exactly the solutions of the system  $A\beta = 0$  of linear equations (where  $\beta$  is the vector of variables). So, by (12) for each  $\beta \in \mathbb{R}^p$  where  $A\beta = 0$  there exists  $\theta \in \mathbb{R}^p$  such  $X_2 \beta = X_1 \theta$  and for each  $\theta \in \mathbb{R}^p$  there exists a solution  $\beta \in \mathbb{R}^p$  of  $A\beta = 0$  such that  $X_1 \theta = X_2 \beta$ . It follows that the model  $L_1$  is the model  $L_2$  constrained by  $A\beta = 0$ . We may conclude that if  $L_1 = (y, X_1 \theta, \sigma^2 D)$  and  $L_2 = (y, X_2 \beta, \sigma^2 D)$  are two linear models with  $X_1 \leq^- X_2$ , then there exists a matrix  $A$  such that  $A\beta$  is estimable in the model  $L_2$  and  $L_1$  is the model  $L_2$  constrained by  $A\beta = 0$ .

We presented the above argument as an example of how purely linear algebraic techniques can lead to a result that has implications in statistics. It turns out that the converse of the proved implication is true as well (Mitra et al., 2010, proof of Theorem 15.3.6).

**Theorem 2** Let  $L_1 = (y, X_1 \theta, \sigma^2 D)$  and  $L_2 = (y, X_2 \beta, \sigma^2 D)$  be any two linear models. Then  $X_1 \leq^- X_2$  if and only if there exists a matrix  $A$  with  $\text{Im} A^t \subseteq \text{Im} X_2^t$  and  $L_1$  is the model  $L_2$  constrained by  $A\beta = 0$ .

The following result gives an interpretation of the left-star order in Gauss-Markov linear models, i.e. linear models  $(y, X\beta, \sigma^2 D)$  where  $D = I$  is the identity matrix.

**Theorem 3** Let  $L_1 = (y, X_1 \beta, \sigma^2 I)$  and  $L_2 = (y, X_2 \beta, \sigma^2 I)$ . Then  $X_1 \leq_* X_2$  if and only if: (i) The linear models  $L_1$  and  $L = (y, (X_2 - X_1)\beta, \sigma^2 I)$  have no common estimable linear function of  $\beta$ ;  
(ii)  $X_1 \beta$  is estimable under the model  $L_2$ ;  
(iii) The BLUE of  $X_1 \beta$  under the model  $L_1$  is also its BLUE under  $L_2$  and the

variance-covariance matrix of the BLUE of  $X_1\beta$  under the model  $L_1$  is the same as under the model  $L_2$ .

With the next result we give another application of the minus partial order (Baksalary & Puntanen, 1990, p. 366).

**Theorem 4** Consider a linear model  $(y, X\beta, \sigma^2D)$ . Then the statistics  $Fy$  is BLUE of  $X\beta$  if and only if the following conditions hold:

- (i)  $FX = X$ ;
- (ii)  $\text{Im}(FD) \subseteq \text{Im}X$ ;
- (iii)  $V(Fy) \leq^- V(y)$ .

Note that  $V(Fy)$  and  $V(y)$  are positive semidefinite matrices. It is thus natural to ask if there are some characterizations (i.e. equivalent definitions) of the minus partial order on the cone of all positive semidefinite matrices. Observe first that if  $A = 0$  is the  $n \times n$  zero matrix, then  $ACA = A$  for every  $C \in M_n(\mathbb{F})$ . Take  $A^- = 0$  to conclude by (4) that  $0 \leq^- B$  for every  $B \in M_n(\mathbb{F})$ .

**Theorem 5** Let  $A, B \in M_n(\mathbb{F})$  be positive semidefinite and  $A \neq 0$ . Then  $A \leq^- B$  if and only if there exists an invertible matrix  $S \in M_n$  such that

$$A = S \begin{bmatrix} I_r & 0 \\ 0 & 0 \end{bmatrix} S^* \quad \text{and} \quad B = S \begin{bmatrix} I_s & 0 \\ 0 & 0 \end{bmatrix} S^*$$

where  $I_r$  and  $I_s$  are  $r \times r$  and  $s \times s$ ,  $s \leq n$ , identity matrices, respectively, and  $r < s$  if  $A \neq B$ , and  $r = s$ , otherwise. (In case when  $s = n$ , the zeros on the right-hand side of the formula for  $B$  are absent.)

This purely linear algebraic result (Golubić & Marovt, in press, Theorem 4.1) may now be used with Theorem 4 to obtain the following corollary.

**Corollary 1** Let  $(y, X\beta, \sigma^2D)$  be a linear model. Then the statistics  $Fy$  with  $V(Fy) \neq V(y)$  is BLUE of  $X\beta$  if and only if the following conditions hold:

- (i)  $FX = X$ ;
- (ii)  $\text{Im}(FD) \subseteq \text{Im}X$ ;
- (iii) There exist an invertible matrix  $S \in M_n(\mathbb{R})$  such that

$$V(Fy) = S \begin{bmatrix} I_r & 0 \\ 0 & 0 \end{bmatrix} S^t \quad \text{and} \quad V(y) = S \begin{bmatrix} I_s & 0 \\ 0 & 0 \end{bmatrix} S^t$$

where  $I_r$  is a  $r \times r$  identity matrix, and  $I_s$  is a  $s \times s$  identity matrix with  $r < s \leq n$ .

We conclude this section with another corollary of Theorem 5. Note that for a positive semidefinite matrix  $A \in M_n(\mathbb{R})$ , the matrix  $W^tAW \in M_m(\mathbb{R})$  is still positive semidefinite for any matrix  $W \in M_{n,m}(\mathbb{R})$ . The following result (Golubić & Marovt, in press, Corollary 4.3) thus follows directly from Theorem 5 and (Baksalary et al., 1992, Theorem 1).

**Corollary 2** Let  $A = \sum_{i=1}^k A_i$  where  $A_i \in M_n(\mathbb{R})$  are positive semidefinite matrices,  $i = 1, 2, \dots, k$ . Let the  $n \times 1$  random vector  $x$  follow a multivariate normal distribution with the mean  $\mu$  and the variance-covariance matrix  $V$ . Let  $W = (V:\mu)$  be a  $n \times (n + 1)$  partitioned matrix. Consider the quadratic forms  $Q = x^t A x$  and  $Q_i = x^t A_i x$ ,  $i = 1, 2, \dots, k$ . Then the following statements are equivalent.

- (i)  $Q_i$ ,  $i = 1, 2, \dots, k$ , are mutually independent and distributed as chi-squared variables;
- (ii)  $Q$  is distributed as a chi-squared variable and there exist invertible matrices  $S_i \in M_{n+1}(\mathbb{R})$  such that

$$W^t A_i W = S_i \begin{bmatrix} I_{r_i} & 0 \\ 0 & 0 \end{bmatrix} S_i^t \quad \text{and} \quad W^t A W = S_i \begin{bmatrix} I_s & 0 \\ 0 & 0 \end{bmatrix} S_i^t$$

for every  $i = 1, 2, \dots, k$ , where  $I_{r_i}$  are  $r_i \times r_i$  identity matrices, and  $I_s$  is a  $s \times s$  identity matrix with  $r_i \leq s \leq n + 1$ . (Here  $I_{r_i} = 0$  if  $W^t A_i W = 0$  for some  $i \in \{1, 2, \dots, k\}$ .)

**Preservers of Partial Orders**

The first example of a solution to a preserver problem dates back to the year 1897 when Frobenius described the form of all bijective, linear maps  $\Phi: M_n(\mathbb{F}) \rightarrow M_n(\mathbb{F})$  that preserve the determinant, i.e.

$$\det \Phi(A) = \det A$$

for every  $A \in M_n(\mathbb{F})$ . Since then many authors studied various preservers problems (see the monograph by Molnár, 2007, and references therein).

Let  $H_n(\mathbb{F})$  denote the set of all Hermitian (i.e. symmetric in the real case) matrices in  $M_n(\mathbb{F})$ , let  $H_n^+(\mathbb{F})$  be the cone of all positive semidefinite matrices in  $H_n(\mathbb{F})$ . Note that if  $A \in M_{m,n}(\mathbb{F})$ , then  $A^* A \in H_n^+(\mathbb{F})$ . We say that two matrices  $A, B \in M_{m,n}(\mathbb{F})$  are ordered as

$$A \leq_N B \quad \text{if and only if} \quad A^* A \leq_L B^* B,$$

i.e.  $B^* B - A^* A \in H_n^+(\mathbb{F})$ . The relation  $\leq_N$  has many applications in statistics, e.g. in the study of of probability measures, in linear estimation theory, in the analysis of the power of a binary hypothesis test, etc (Jensen, 1984, Part 2). In some of these applications order-preserving maps are used; e.g. in (Jensen, 1984, Application 3) author uses maps  $\Phi: M_{m,n}(\mathbb{R}) \rightarrow \mathbb{R}$ , defined with  $\Phi(A) = \varphi(A^t A)$ ,  $A \in M_{m,n}(\mathbb{R})$ , where  $\varphi: H_n^+(\mathbb{R}) \rightarrow \mathbb{R}$  is an order-preserving map in one direction with respect to the Löwner partial order, i.e.

$$A \leq_L B \quad \text{implies} \quad \Phi(A) \leq \Phi(B)$$

for every  $A, B \in H_n^+(\mathbb{R})$ . It is thus natural to study and try to characterize transformations on  $H_n^+(\mathbb{R})$  that have a ‘Löwner order-preserving property’ (i.e. maps that either preserve the Löwner partial order in one or in both directions, the latter in the sense of (10)), and perhaps have some additional properties. Moreover, in modern high-dimensional probability theory and statistics, transformations are often applied to the entries of variance-covariance matrices in order to obtain regularized estimators with attractive properties (sparsity, good condition number, etc.), see Bickel and Levina (2008). The resulting matrices often serve as ingredients in statistical procedures that require these matrices to be positive semidefinite (Guillot et al., 2015).

Motivated by applications in quantum information theory and quantum statistics Molnár studied preservers that are connected to certain structures of bounded linear operators which appear in mathematical foundations of quantum mechanics, i.e. he studied automorphisms of the underlying quantum structures or, in other words, quantum mechanical symmetries. From one of Molnár’s results (Molnár, 2001, Theorem 1) it follows that bijective maps  $\Phi: H_n^+(\mathbb{C}) \rightarrow H_n^+(\mathbb{C})$ ,  $n \geq 2$ , where  $A \leq^L B$  if and only if  $\Phi(A) \leq^L \Phi(B)$ ,  $A, B \in H_n^+(\mathbb{C})$ , are of the form

$$\Phi(A) = TAT^*, \quad A \in H_n^+(\mathbb{C}) \tag{13}$$

where  $T \in M_n(\mathbb{C})$  is an invertible matrix. Motivated by possible applications in statistics authors studied in (Golubić & Marovt, in press) bi-preservers on  $H_n^+(\mathbb{R})$  of the Löwner partial order. They showed that a similar theorem to Molnár’s result (13) holds also in the real matrix case.

**Theorem 6** *Let  $n \geq 2$  be an integer. Then  $\varphi: H_n^+(\mathbb{R}) \rightarrow H_n^+(\mathbb{R})$  is a surjective bi-preserver of the Löwner partial order  $\leq^L$  if and only if there exists an invertible matrix  $S \in M_n(\mathbb{R})$  such that*

$$\varphi(A) = SAS^t$$

for every  $A \in H_n^+(\mathbb{R})$ .

The following observation is connected to the theory of comparison of linear models and was presented in (Golubić & Marovt, in press).

**Remark** Let  $L_1 = (y_1, X_1\beta, \sigma^2 D_1)$  and  $L_2 = (y_2, X_2\beta, \sigma^2 D_2)$  be two linear models. Here  $X_1 \in M_{n,p}(\mathbb{R})$ ,  $X_2 \in M_{m,p}(\mathbb{R})$ ,  $D_1 \in H_n^+(\mathbb{R})$ , and  $D_2 \in H_m^+(\mathbb{R})$ . Recall that  $L_1 \geq L_2$  means that the model  $L_1$  is at least as good as the model  $L_2$  and that by Theorem 1

$$L_1 \geq L_2 \quad \text{if and only if} \quad M_2 \leq^L M_1$$

where  $M_i = X_i^t (D_i + X_i X_i^t)^- X_i$ ,  $i \in \{1, 2\}$ . Moreover, Stępniaik noted in (Stępniaik, 1985) that when  $\text{Im} X_i \subseteq \text{Im} D_i$ ,  $i \in \{1, 2\}$ , we may replace  $X_i^t (D_i + X_i X_i^t)^- X_i$  with

$X_i^t D_i^- X_i$ . When  $D_i = X_i$ ,  $i \in \{1, 2\}$ , these matrices may be further simplified to  $M_i = X_i^t D_i^- X_i = D_i^t D_i^- D_i = D_i D_i^- D_i = D_i$ . For models  $L_1 = (y_1, D_1 \beta, \sigma^2 D_1)$  and  $L_2 = (y_2, D_2 \beta, \sigma^2 D_2)$  we thus have

$$L_1 \geq L_2 \quad \text{if and only if} \quad D_2 \leq^L D_1.$$

Let  $n > 1$ . For a random  $n \times 1$  vector of observed quantities  $y_i$ , an unspecified  $n \times 1$  vector  $\beta_i$ , and an unspecified nonnegative scalar  $\sigma_i^2$ , let  $\mathcal{L}_i$  be the set of all linear models  $L_i = (y_i, D \beta_i, \sigma_i^2 D)$  where  $D \in H_n^+(\mathbb{R})$  may vary from model to model. Define a map  $\psi: \mathcal{L}_1 \rightarrow \mathcal{L}_2$  with  $\psi((y_1, D \beta_1, \sigma_1^2 D)) = (y_2, \varphi(D) \beta_2, \sigma_2^2 \varphi(D))$  where  $\varphi: H_n^+(\mathbb{R}) \rightarrow H_n^+(\mathbb{R})$  is a surjective map. Suppose

$$L_{1_a} \geq L_{1_b} \quad \text{if and only if} \quad \psi(L_{1_a}) \geq \psi(L_{1_b})$$

for every  $L_{1_a}, L_{1_b} \in \mathcal{L}_1$ . This assumption may be reformulated as  $D_{1_b} \leq^L D_{1_a}$  if and only if  $\varphi(D_{1_b}) \leq^L \varphi(D_{1_a})$ ,  $D_{1_a}, D_{1_b} \in H_n^+(\mathbb{R})$ , and therefore Theorem 6 completely determines the form of any such a map  $\psi$ .

Let  $A, B \in H_n(\mathbb{F})$ . Since then  $A^* A = A^* B$  if and only if  $(A^* A)^* = (A^* B)^*$  if and only if  $A^2 = BA$  which is equivalent to  $AA^* = BA^*$ , we may conclude (compare (5) with (6) and (7)) that the star, the left-star, and the right-star partial orders are the same partial order on  $H_n(\mathbb{F})$ . They are however different to the minus partial order even on  $H_n^+(\mathbb{F})$  (see Golubić & Marovt, 2020, for a counterexample). Motivated by applications of the minus and the left-star partial orders in the linear model theory (see Theorems 3, 4) authors characterized in (Golubić & Marovt, in press, 2020) the surjective, additive minus and star partial order bi-preservers on  $H_n^+(\mathbb{R})$ ,  $n \geq 3$ . We present here a result concerning the star partial order bi-preservers. Recall that  $A \in M_n(\mathbb{R})$  is called an orthogonal matrix when  $A^t A = AA^t = I$ , i.e. when  $A^t = A^{-1}$  where  $A^{-1}$  denotes the usual inverse of an invertible matrix  $A$ .

**Theorem 7** *Let  $n \geq 3$  be an integer. Then  $\varphi: H_n^+(\mathbb{R}) \rightarrow H_n^+(\mathbb{R})$  is a surjective, additive bi-preserver of the star partial order if and only if there exists an orthogonal matrix  $R \in M_n(\mathbb{R})$  and  $\lambda > 0$  such that*

$$\varphi(A) = \lambda R A R^t$$

for every  $A \in H_n^+(\mathbb{R})$ .

We end the paper with a remark that in a very recent paper (Dolinar et al., 2020) the forms of general (not necessarily additive) surjective bi-preservers of the left-star partial order and the right-star partial order on  $M_n(\mathbb{F})$ ,  $n \geq 3$ , were described. The results, which were expressed by using the Moore-Penrose inverse, are rather technical and hence we omit them. Nevertheless we mention that it was noted in (Dolinar et al., 2020) that

given the model  $M = (y, X\beta, \sigma^2 I)$  one might rather work with the transformed model  $\hat{M} = (y, \hat{X}\beta, \sigma^2 I)$  because the matrix  $\hat{X} \in M_n(\mathbb{R})$  has more attractive properties than  $X \in M_n(\mathbb{R})$  (e.g. elements of  $X$  that are very close to zero are transformed to zero), and thus it is natural to demand that the transformed model still retains most of the properties of the original model (e.g. has similar relations to other transformed models). Thus, in view of Theorem 3, it is interesting to know what transformations on  $M_n(\mathbb{R})$  preserve the left-star partial order in both directions.

We believe that preservers of various relations on sets of matrices hold a great potential for applications in statistics and hope that our review of ‘preserver results’ might encourage some statisticians and/or mathematicians to find further connections between certain bi-preservers and statistics.

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## Abstracts in Slovene

### **Strokovno učenje iz nepravilnosti v sistemu zdravstva: menedžerizem in sočutje**

*Katie Willocks, Jem Bendell in Richard Little*

Študija išče odgovor na vprašanje: kakšna vedenja lahko preobrazijo poklicne nepravilnosti v porodniških oddelkih v priložnosti za učenje znotraj zdravstvenega sistema in kako lahko modeli upravljanja in vodenja vplivajo na ta proces. Neustrezno sodelovanje kot posledica nezadostno opredeljenih vlog in razlik v profesionalnem statusu predstavljata osnovo za v okviru Teorije kulturnozgodovinske dejavnosti izvedeno analizo. O posledičnih vplivih na poklicno učenje se razpravlja v okvirjih, ki lahko pripomorejo k skladnosti in uporabnosti prihodnjih raziskav. Morebitne izboljšave na področju poklicnega učenja bi morale odražati splošno sočutni etos, kot opozorilo na zaveze in dejavnosti zdravstvenih delavcev.

*Ključne besede:* vodstvo, sočutje, menedžerizem, zdravstvo, materinstvo, Teorija kulturnozgodovinske dejavnosti

IJKML, 9(2), 129–151

### **Razumevanje podjetniških namer na podlagi Teorije načrtovanega vedenja med študenti podjetništva v Albaniji**

*Blendi Shima in Babu George*

Cilj raziskave je prispevati k razumevanju vpliva podjetniškega izobraževanja na podjetniške namene med univerzitetnimi študenti podjetništva v Albaniji. Na podlagi Teorije načrtovanega vedenja je predlagan model, ki povezuje podjetniško izobraževanje in podjetniško namero. Z izobraževanjem povezani dejavniki vpliva na podjetniške namere študentov podjetništva v Albaniji so opredeljeni in izmerjeni. Analiza podatkov razkriva pomembne povezave med osebnim odnosom in podjetniškimi namerami. Subjektivne norme in zaznani nadzor nad podjetniškimi sposobnostmi nimajo pomembnejšega vpliva na podjetniške namere. Predstavljena je razprava o rezultatih in predlagane bodoče raziskovalne možnosti.

*Ključne besede:* podjetniško izobraževanje, teorija načrtovanega vedenja, podjetniška namera, zaznana zaželjenost, zaznan podjetniški nadzor, subjektivne norme

IJKML, 9(2), 153–167

### Upravljanje zalog v okviru korporacije: študija primera

*Juha Lukkarinen and Jukka Majava*

Inventarji in upravljanje zalog so sestavni deli dobavne verige in logističnih dejavnosti. Študija analizira upravljanje zalog znotraj korporacije in s tem povezane edinstvene izzive. Gre za kvalitativno študijo, izvedena pa je tudi študija primerov iz prakse upravljanja zalog. Ugotovitve poudarjajo pomen zanesljivosti inventarnih podatkov, prakse dokumentiranja in poenotene organizacije upravljanja zalog. Opozarjajo pa tudi na težave in potrebe po razvoju. Ker je bila izvedena le ena študija primera, rezultatov ni mogoče posploševati. Vendar pa vodstveni delavci lahko ugotovitve kljub temu uporabijo kot referenco pri razvojnih projektih upravljanja zalog v korporacijah.

*Ključne besede:* inventar, upravljanje zalog, korporacija, upravljanje dobavne verige, logistika

IJMKL, 9(2), 169–184

### Preprečevanje nastanka potreb po finančnem okrevanju podjetij s pomočjo sistema zgodnjega opozarjanja

*Ramon Oehninger, Michael J. Kendzia in Felix Scherrer*

Stečaji so v poslovnem svetu vse prej kot nov pojav. Najnovejši primeri, ki zajemajo podjetja Toys R Us, Fred's in Sears v ZDA, ter Thomas Cook in Air Italy v Evropi kažejo, da vodstveni delavci pri svojem delu pogosto niso najbolj uspešni. Morebitni stečaj je mogoče preprečiti z uvedbo načina upravljanja, ki zahteva temeljito prenovo podjetja, a poznavanje in izvajanje sistema zgodnjega opozarjanja (Early Warning System – EWS) bi lahko morebitne tovrstne potrebe preprečilo že vnaprej. Pri tem je ključno, da se vodstveni delavci seznanijo s pragmatičnim in k rešitvam usmerjenim pristopom. V ta namen avtorji oblikujejo poseben sistem zgodnjega opozarjanja, ki bi lahko že zelo zgodaj v procesu pripomogel k temu, da do potreb po prenovi podjetij sploh ne bi prihajalo. Prispevek je torej namenjen razširjanju informacij o boljših in učinkovitejših sistemih zgodnjega opozarjanja za javna podjetja.

*Ključne besede:* sistem zgodnjega opozarjanja, stečajno upravljanje, finančna razmerja

IJMKL, 9(2), 185–205

### Vključevanje IKT v rabo avtentičnih gradiv pri poučevanju angleškega jezika za posebne namene v visokošolskih zavodih

*Tamar Dolidze and Natela Doghonadze*

Živimo v svetu napredne tehnologije in ker je IKT osnova za delovanje e-učilnic, s katerimi se v učnem procesu srečuje večina učencev, je izraz tehnološka integracija v učnem procesu v izobraževanju dandanes eden najbolj pogosto in najširše uporabljenih. V zadnjem času, še posebej po izbruhu COVID-19, je tehnološka integracija postala ne le priporočljiv, temveč tudi neizogiben način izvajanja katerega koli akademskega procesa, vključno s poučevanjem

angleščine kot tujega jezika (EFL) in angleščine za posebne namene (ESP). V prispevku skušamo še enkrat poudariti pomen vključevanja tehnologij za učinkovito uporabo avtentičnih materialov, kot so npr. TED pogovori, prenosi v živo itd., v poučevanje angleščine za posebne namene na ravni terciarnega izobraževanja v Gruziji. V ta namen je bila izvedena tudi raziskava, v kateri so sodelovali strokovnjaki za poučevanje angleščine za posebne namene. Rezultati kažejo, da je uporaba IKT pri poučevanju/učenju angleščine za posebne namene najsoodnejši pristop, ki pri učencih povečuje tako motivacijo, angažiranost, samostojnost, kot tudi raven jezikovnega znanja. K temu močno pripomore avtentičnost materialov. Prispevek priporoča več uporabe IKT pri pouku angleščine za posebne namene, saj uporabljena gradiva in metode poučevanja prinašajo večjo raznolikost.

*Ključne besede:* informacijska in komunikacijska tehnologija (IKT), angleščina za posebne namene (ESP), avtentična gradiva, avtonomija učenca, zavzetost, jezikovno znanje

IJMKL, 9(2), 207–221

### **O nekaterih aplikacijah matričnih delnih urejenosti v statistiki**

*Iva Golubič in Janko Marovt*

Različne matrične delne urejenosti se v statistiki pogosto izkažejo kot koristne. Tri najbolj znane delne urejenosti, ki jih definiramo na (pod)množicah realnih ali kompleksnih matrik, so Löwnerjeva delna urejenost, minus delna urejenost in zvezdica delna urejenost. Še dve delni urejenosti, ki sta povezani z zvezdica delno urejenostjo, sta leva-zvezdica in desna-zvezdica delni urejenosti. V članku podamo pregled nekaterih aplikacij omenjenih matričnih delnih urejenosti v statistiki.

*Ključne besede:* matrična delna urejenost, posplošeni matrični inverz, ohranjevalec, statistika, linearni model

IJMKL, 9(2), 223–235



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