

**PART 1: THE ROLE OF WASTE DATA IN BUILDING KNOWLEDGE:
THE SOUTH AFRICAN WASTE INFORMATION SYSTEM**

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Abstract

An empirical study was undertaken with 31 organisations submitting data to the South African Waste Information System (SAWIS) in order to explore the relationship between data and resultant waste knowledge. The results show that of the three constructs of knowledge (experience, data/information, and theory), experience has the greatest influence on building waste knowledge, nearly twice that of data/information and three times that of theory. Together the three constructs account for 54.1% of the variance in knowledge. Respondents from municipalities and private waste organisations reflect two distinct sub-groups in the data set. While the theoretical model remains the same for the two sub-groups, the way in which knowledge is constructed, and the variance in knowledge explained by the model, differs for the two. A mixed methods research design, combining quantitative statistical analysis and rich qualitative data, contributes to a comprehensive interpretation of the role of waste data in building knowledge in South Africa. While waste data has a minor influence on building knowledge, respondents acknowledge that waste data does have a positive impact on the way their organisations manage waste. However, it is not the data, but rather the resultant waste knowledge and raised level of awareness that causes the operational response. Experience is obtained predominantly through learning from others. Respondents in municipalities, emphasised learning from consultants, landfill site contractors, and colleagues in city-twinning programmes, while respondents in private waste companies, emphasised learning from experienced, senior colleagues.

Keywords: waste knowledge, waste information system, waste data, process of learning

1. Introduction

The South African Department of Environmental Affairs (DEA) developed and implemented the South African Waste Information System (SAWIS) in 2006. The system, which requires reporting by waste landfills, treatment facilities and reprocessors, was designed to “*support the improvement of integrated waste management in South Africa through the dissemination and use of reliable waste information, thereby ensuring the protection of the environment and human health*” (DEAT, 2005:1). Reporting to SAWIS has remained voluntary since its rollout in 2006. Waste activities reporting to SAWIS have increased from 25 to 46 between 2006 and 2011. Draft regulations are currently being developed by DEA to enforce reporting to the system. While the SAWIS may have been intended simply as a means to collect and report waste data for the country, this research explores whether the collection of waste data creates opportunities for learning, raised awareness and resultant behavioural change. The South African government has set a path to building a knowledge-based economy by 2018 recognising the value of knowledge workers in creating a globally competitive economy and sustaining economic growth (Scardamalia & Bereiter, 2003; DST, 2007; Illeris, 2009). In addition, waste management in South Africa is becoming more technologically demanding, the business more competitive and with increasing costs and legislative requirements, profit margins smaller. Knowledgeable persons within the waste sector are therefore crucial to the improvement of waste management in the country.

Godfrey & Scott (2011) showed in an empirical study undertaken in 2006, that some respondents from the South African waste sector had assimilated and interpreted the waste data collected for SAWIS, which had through a learning process, built new knowledge. This raised respondents’ awareness of issues such as vehicle management, facility planning, costing of operations, and ongoing site operation and maintenance. However, there were persons who did not use the data after having collected it, and therefore did not see the usefulness in having the data available to them, or had a poor understanding of the potential use of the data, resulting in no or little noticeable impact on operations. The 2006 study used Miller and Morris’ (1999) process of learning (**Figure 1**) as a theoretical framework to assess, by means of qualitative methods, the influence of waste data and information in building knowledge. Godfrey & Scott (2011) showed that the preliminary theoretical framework of learning was inadequate for understanding the role of waste data in a developing country context such as South Africa, in that it did not account for the influence of external societal forces. The authors proposed that further research be undertaken, by applying a more conceptually inclusive framework that accounts for the complex nature of learning, behaviour, and potential for action from waste data collection, within the broader societal context of South African as a developing country in the process of transformation.

This paper builds upon the research of Godfrey & Scott (2011) by extending the theoretical framework to allow the authors to more adequately explain the influence of data on behaviour. The study, undertaken in 2011, is therefore the second empirical study by the lead author to explore the influence of waste data in changing the way waste is managed. Given the wealth of information in the findings of this study, the results are presented in two papers. In this first paper, the authors re-examine the relationship between data, theory, and experience in building waste knowledge in 2011, using both quantitative and qualitative research methods. Quantitative methods were not possible in the 2006 empirical study given the small population size. The aim of this paper is to understand the role of three constructs (data, theory and experience), and specifically waste data, in the creation of waste knowledge. The paper also reflects on whether changes in waste data use have occurred in the South African context between 2006 and 2011. The second paper (Godfrey et al., forthcoming) builds on the process of learning, to examine the influence of data and knowledge on waste behaviour.

2. Theoretical framework

2.1 Learning

There are many learning theories and paradigms applied mostly in the fields of education and educational psychology (Illeris, 2009). While learning is traditionally considered to be the acquisition of knowledge and skills, more recent approaches to learning consider aspects such as emotional, social and societal dimensions, with the result that there is no generally accepted definition of the concept (Illeris, 2009). Miller & Morris' process of learning, taken from the field of knowledge management, specifically identifies data as a construct of knowledge building. This conceptualisation is particularly relevant to the research question explored here and hence its adoption as a theoretical framework.

The process of learning put forward by Miller and Morris (1999) proposes that data, theory, and experience each contribute to the creation of knowledge (**Figure 1**). It shows how collected data is assimilated, interpreted (converted to information) and together with the application of existing theory (which puts that information into the correct context) and experience of real world applications, builds knowledge (Allee, 1997; Miller & Morris, 1999; Poch *et al.*, 2004). Knowledge, which is considered by Allee (2003:264) to be "*the capacity to act*", is seen as an important component of attitude formation and of behaviour. According to Miller & Morris (1999) without any one of the three constructs, learning does not take place and knowledge is not created. Their process of learning is constructivist in nature, where the individual actively builds and constructs their knowledge. Learning, on the other hand, is considered to be a process of "*gaining knowledge, comprehension or mastery*", "*acquiring or creating knowledge*" (Allee, 1997:50) or as a relatively permanent change in

behaviour or behaviour potential (Bandura, 1977; Baron, 1995). Scardamalia and Bereiter (2003) see learning as an internal, almost unobservable process resulting in changes in beliefs, attitudes, or skills.

2.2 Hypotheses

The intention of the research is to explore the question “*Can the collection of data for a national waste information system change the way waste is managed in South Africa, such that there is a noticeable improvement?*” While the relationship between data and behaviour is explored by Godfrey et al. (forthcoming), this paper focuses on a specific sub-question of this research, namely whether the collection of data for the SAWIS can build waste knowledge.

This sub-question is explored by examining the way in which experience, data/information, and theory influence the creation of knowledge through the following three hypotheses (**Figure 1**):

H₁. Personal waste experience has a positive effect on building waste knowledge

H₂. Waste data (and information) have a positive effect on building waste knowledge

H₃. Waste theory has a positive effect on building waste knowledge

Since participating organisations assimilate their waste data into waste information before submitting it to the SAWIS, data and information are treated as a single construct for the purposes of this research.

3. Method

3.1 Participants

In order to fully investigate the research question, participating organisations must have recently submitted data to the SAWIS. There are two main types of organisation that report data to SAWIS, namely public organisations (municipalities), and private organisations (itself of two types: industrial and private waste companies). The population of possible participants in the research was therefore limited to those organisations that had submitted data to the SAWIS in 2009 and 2010. Only 32 organisations reported to SAWIS in both 2009 and 2010, two organisations in 2009 only, and six organisations in 2010 only, giving 40 unique organisations (14 municipal, 26 private). Because of the small population size (n=40), sampling was felt to be unnecessary and all organisations were approached to participate in the research.

Certain organisations are submitting data for more than one waste activity (**Table 2**). Waste activities are identified in SAWIS as individual landfill sites, treatment facilities or reprocessors. Waste

generators and transporters are presently not required to submit data to SAWIS at present (DEAT, 2005). The number of reporting activities represents only a small fraction of operating waste facilities in the country. According to the landfill census conducted as part of the transfer of the waste permitting function there were a total of 226 operating medium and large general and hazardous waste landfills as at 2005/06 (DEAT, 2006). Landfills currently reporting data to SAWIS therefore represent an estimated 12-13% of currently operating landfills that are required to submit data. However, since reporting to SAWIS is still voluntary, such low figures can be expected (Godfrey, 2004). Voluntary waste data reporting programmes in Mexico showed only 5% of industries provided information (CEC, 2004; Nauman, 2004) whereas in Israel, 40-60% of local authorities voluntarily reported waste data (Sheshinksi, 2002). Even though still voluntary in South Africa, reporting to SAWIS has increased from 25 to 46 waste activities between 2006 and 2011. With no national data on the total number of operating treatment facilities or waste reprocessors, it is not possible to comment on the percentage of these activities reporting, however it is also considered to be low.

Respondents were identified within each of the participating organisations as the registered system user or person responsible for capturing and submitting the waste data to SAWIS. Of the 40 participating organisations, two were no longer contactable and seven organisations did not make themselves available to participate in the study. In certain organisations, the responsibility for capturing and uploading the data has been split between different persons. In these cases, both persons were approached for interviews. From the 31 available organisations, 44 respondents participated in the study (15 municipal, 29 private).

3.2 Procedure

Given the small population size and the resultant limitations on the methods of quantitative analysis that can be used, the research adopted a hybrid or mixed-method design, combining both quantitative and qualitative research methods (Leedy & Ormrod, 2005; Moser & Felton, 2010). In so doing, the authors aim to explore the relationships between the theoretical constructs by means of quantitative data (and associated statistical analysis), while at the same time seeking a deeper understanding in these relationships through the rich qualitative data. In this way, a fuller understanding is obtained as to the role of data in building waste knowledge in South Africa.

Data were collected by means of semi-structured interviews, each lasting approximately one hour, during which a questionnaire was administered. The questionnaire consisted of two parts, Part I being a questionnaire of 57 closed questions to elicit quantitative data, and Part II being an interview schedule of 11 open questions, administered by the lead researcher, to guide the discussion and elicit

qualitative data. Of the 57 closed and 11 open questions, 24 closed and three open questions relate specifically to this research paper, i.e. those questions related to the constructs of knowledge.

3.3 Quantitative data collection

Each of the three constructs (data/information, theory, experience) were measured by means of a seven point semantic differential scale, ranging from 1 to 7 (strongly disagree/strongly agree). Questions assessing the same construct were interspersed with those of other constructs to ensure a non-systematic order to the questions, thereby reducing the chance for response bias on sets of questions (Ajzen, 2006). Self-reported waste knowledge was measured on a scale of 1 = “poor” to 7 = “excellent”.

Following the recommendations of Tenenhaus et al. (2005), Henseler et al. (2009), and Vinzi et al. (2010), the reliability of each set of questions (i.e. instrument) was assessed using Dillon and Goldstein's rho (ρ); dimensionality was assessed using the size of the first eigenvalue relative to the second. Dillon and Goldstein's rho is a composite measure of internal consistency reliability that is well-suited to the partial least squares path modelling method of analysis used here. For exploratory work, ρ should be equal to or greater than 0.7 (Vinzi et al., 2010). Instruments are considered to be unidimensional if the first eigenvalue is greater than one, and the second eigenvalue less than one; or if the first eigenvalue is much greater than the second. Although it is no longer considered to be a good measure of reliability (Sijtsma, 2009), the authors also report Cronbach's alpha (α), since it is still widely used.

3.3.1 Data/Information

Two items were used to measure the role of data in the creation of respondents' waste knowledge. These are: “*I have built my waste knowledge mostly through collecting and analysing waste data*”, and “*Collecting waste data has been an important way of learning about waste management for me*”. The instrument is unidimensional and internal consistency reliability is good to very good (**Table 3**).

3.3.2 Theory

Two items were used to measure the role of theory in the creation of respondents' waste knowledge. These are: “*I have built my waste knowledge mostly through courses/training/degrees*”, and “*Studying and attending courses has been an important way of learning about waste management for me*”. The instrument is unidimensional and internal consistency reliability is excellent (**Table 3**).

3.3.3 Experience

Two items were used to measure the role of personal experience in the creation of respondents' waste knowledge. These are: "*I have built my waste knowledge mostly through practical experience on waste projects*", and "*Working on real waste projects has been an important way of learning about waste management for me*". The instrument is unidimensional and internal consistency reliability is adequate to good (Table 3).

3.4 Qualitative data collection

In addition to the closed questions, the following open questions were posed to stimulate discussion: "*Was your organisation collecting waste data before it was required for SAWIS, and if yes, for what reason were you collecting data?*", "*What do you feel have been the three most significant activities/events/ experiences in your career that have contributed to your current waste knowledge?*", and "*What have you personally learnt about waste management in your organisation from the waste data that you are collecting for SAWIS?*" These questions provided insight into the socially constructed meaning of data in building waste knowledge in public and private waste organisations in South African.

3.5 Data analysis and interpretation

Due to the small population size (participating organisations) from which samples were drawn, partial least squares path modelling (PLSPM) was used to analyse the data. Traditional structural equation modelling (SEM) is a large-sample method, requiring hundreds, or even thousands, of samples (see Henseler et al., 2009). Traditional SEM also makes strong distributional assumptions. The PLSPM method, in contrast, makes few assumptions and is suitable for use with small to very small data sets (Henseler et al., 2009). Partial least squares path modelling is component-based whereas SEM is covariance-based; nevertheless, the results of the two methods are often similar (Tenenhaus, 2008; Vinzi et al., 2010). The latent variables were estimated using a measurement model as described in Section 3.3. All measurement instruments were unidimensional, had high reliability, and needed no further modification. The theoretical or structural model, as described in Section 2. (**Figure 1**) was fitted using the latent variables estimated by the measurement model. The results are presented in terms of the path diagram as shown in **Figure 2**. The path diagram consists of a set of regression (or path) coefficients (β) showing the influence of the input variables on the target variable (*knowledge*), and the coefficients of determination (R^2), which gives an indication of the amount of variance of the target variable that the model explains.

Having adopted a mixed research method, data analysis also included an interpretation of the qualitative data. A large body of interview transcript data was sorted and categorized into a small set of pertinent themes (Leedy and Ormond, 2005). In the thematic analysis, two techniques were chosen for interpretation of the research data; pattern matching and explanation building (Yin, 2003). Content analysis (Whitley, 2002) was also applied to interpreting the qualitative data. This allowed the authors to delve into the meaning, perceptions, and beliefs of respondents regarding the construction of knowledge. Interpreting the qualitative data provided deeper insights into the research question and served to corroborate the findings of the statistical analysis. Due to the adopted mixed methods research approach, results are presented as statistics, narrative, and category (thematic) trees.

During the interviews, and in the analysis of the qualitative data, there were signs of significant differences in responses by respondents from the two types of organisations, i.e. public and private. To test this, a segmentation tree analysis (Sanchez, 2009) was carried out. Type of organisation (whether municipal or private) was found to provide the basis for a significant split in the data set ($p = 0.0008$), indicating the presence of two local models. The structural model is the same in the two models, but there were found to be significant differences between one or more of the path or regression coefficients in each part of the data, based on a modified F-test (Sanchez, 2009). This means that there are significantly different forces at work in public and private waste organisations. This distinction between organisational types is shown to be significant in the analysis of the data.

4. Results

4.1 Statistical analysis of quantitative data

4.1.1 *Global model*

The structural model for the whole data set shows that of the three antecedents to knowledge, experience ($\beta = 0.466$) has the greatest influence on building waste knowledge, with minor influences from information ($\beta = 0.250$) and theory ($\beta = 0.141$). Together the three variables account for 54.1% of the variance in knowledge ($R^2=0.541$).

The analysis of the qualitative data corroborates the statistics presented in **Figure 2** and thus provides some confidence in these results, despite the small population size. These findings are discussed in further detail in the following sections.

4.1.2 Local models

Segmentation-tree analysis reveals that there are in fact two sub-groups in the data set, namely a *Municipal* local model and a *Private* local model. These sub-groups are subject to different influences, impulses and behaviours. Given the small population size and even smaller sub-population size, validation of these results should be undertaken in future research when the number of respondents submitting data to SAWIS has significantly increased.

The *Municipal* local model shows that theory ($\beta = 0.483$) and information ($\beta = 0.429$) have the greatest influence on building waste knowledge, with little influence from experience ($\beta = 0.144$). This is contrary to what we see in the global model (**Figure 2**). Together the three constructs account for 49.5% of the variance in knowledge of municipal respondents ($R^2=0.495$). The *Private* local model shows that experience ($\beta = 0.696$) has the greatest influence on building waste knowledge, with little influence from information ($\beta = 0.115$) and theory ($\beta = 0.202$). This is in agreement with the global model (**Figure 2**), highlighting the impact of the dominant local model on the global model. Together the three constructs account for 77.9% of the variance in knowledge of private respondents.

Of the three hypotheses, H_1 is supported in the *Private* local model, while H_2 and H_3 are supported in the *Municipal* local model. For the global model, H_1 is supported, with experience shown to have the greatest influence on building waste knowledge, nearly twice that of data/information. The fact that there appear to be differences in the way in which knowledge is created between public and private organisations is consistent with Illeris' (2009) model of learning. Illeris (2009) combines traditional behaviourist and cognitive learning theories with modern social learning theories by recognising both internal and external conditions. As a largely traditional learning theory, Miller & Morris' (1999) process of learning does not account for external conditions in the learning process, but focuses on what Illeris (2009:9) calls "*the psychological acquisition process*".

4.1.3 Self reported waste knowledge

Current levels of self-reported technical waste knowledge differ slightly for municipal ($\bar{x} = 5.60$, $SD = 0.99$) and private sector respondents ($\bar{x} = 5.21$, $SD = 1.35$), with municipal respondents reporting on average a higher level of technical waste knowledge than private sector respondents. No significant correlation (at the 10% level of significance) was found between self-reported waste knowledge and respondent age for municipal respondents ($r = 0.34$) or private respondents ($r = 0.07$). A weak correlation (at the 10% level of significance) was found between self-reported waste knowledge and

years of waste experience, both for municipal respondents ($r = 0.54$) and for private sector respondents ($r = 0.43$), as might be expected. High scores (5-7) of self-reported waste knowledge are particularly evident in respondents aged 20-39 years and with less than 5 years experience, suggesting that self-reported knowledge is not an accurate reflection of actual levels of waste knowledge. Self-reports are known to be subject to social desirability response bias (Whitley, 2002). In addition, self-reported waste knowledge is a very subjective response. An inexperienced, young respondent could report a very high level of waste knowledge relative to an experienced waste professional, simply because they are not aware of the full extent of possible knowledge.

4.2 Qualitative analysis of knowledge building

Analysis of the open question: “*What do you feel have been the three most significant activities/events/experiences in your career that have contributed to your current waste knowledge*”, shows that there is a strong tendency towards experience as the main means of learning. Content analysis of this question shows that 67.7% of first responses favour experience, 25.8% theory and 6.5% data/information. These results are consistent with the results of the partial least squares path analysis (**Figure 2**) which shows that, of the three constructs, experience has the greatest influence ($\beta = 0.466$) on building waste knowledge in South Africa. Both the quantitative and qualitative data show that theory and data/information are not as significant as experience in building waste knowledge. However, their order of significance differs between the two methods of analysis, with the statistical results showing a greater influence of data/information than of theory.

The content analysis revealed that while experience remains the dominant means of learning for both private sector (73.7% of first responses) and municipal (58.3%) respondents, theory has a greater influence for municipal respondents (33.3%) than for private sector respondents (21.1%). Data/information plays a minor role for both municipal and private respondents at 8.3% and 5.3% respectively. This differs from the evidence provided by the local models (**Figure 3**), where, for municipal respondents, the statistical results suggest a greater influence from data/information and theory, on knowledge construction, than from experience.

Through the interpretation of the qualitative data, the following sections provide insight into the socially constructed meaning of the three constructs (data, theory and experience), in relation to the creation of waste knowledge.

4.2.1 Data

In analysing the open question: “*What have you personally learnt from the waste data*”, 42.1% of respondents feel that they have not learnt from the data. The remaining respondents, while acknowledging that they have learnt from the data, find it difficult to put this learning into words. At best, respondents acknowledge a better sense of ‘knowing’ about the waste they receive (Respondent 5, 7, 13, 19, 23, 36), or have developed insights into the data through regular analysis, which allows them to detect discrepancies in the data (Respondent 2, 6, 15). While respondents do not have a clear sense of what they have learnt from the data, there is a sense that collecting data has had a positive impact on the way their organisation manages its waste. This may be because learning from data is subtle and often difficult to distinguish from other influences, with the result that it may not be obvious to someone that they have been through a learning process (Denisov and Christoffersen, 2001; Jones, 2001; Zito & Schout, 2009). This is what Scardamalia and Bereiter (2003) refer to as an internal, almost unobservable process. While respondents feel that collecting waste data has a positive impact on the way their organisations manage their waste, they do not feel that the data per se has been the cause of the operational responses in the organisation. It therefore appears to be knowledge, and not data, that is directly responsible for causing operational responses in organisations. This is discussed further in Godfrey et al., (forthcoming).

4.2.2 Theory

As with data, respondents did not see theory as being a major contributor to building their waste knowledge:

“I think it’s very important to have a certain theoretical knowledge. It’s very important to have that, but I think you only really start learning once you’re working at a [landfill] site. Being on site, practically seeing what happens when you implement certain things, you can’t get away from that practical knowledge as well” (Respondent 22).

This response is understandable, given that there are no specific waste management degrees or diplomas offered in South Africa. Waste is typically included as a module in environmental management or engineering degrees: “*You don’t really learn waste from university. You learn pure chemistry and reactions. Now with the waste, it’s unexpected reactions sometimes*” (Respondent 23). However, there has been an increase in waste management seminars, conferences, and training courses offered by private and public institutions, which do help in building the knowledge of those in the waste sector.

4.2.3 Experience

“I’ve been in the waste industry for the last 20 years. So I’ve built up a lot of knowledge through the years, experience” (Respondent 36).

A content analysis of all experiential learning responses, reveals two main categories (i) direct learning through ‘self’, e.g. day-to-day activities and practical waste projects; and (ii) learning from the experience of others, while on the job, e.g. site contractors, experienced colleagues. There is a very close split between these two categories, with 51.0% of responses favouring gaining experience through learning from others on the job and 49.0% of responses favouring gaining experience through self-learning. This highlights the importance of having access to experienced colleagues and service providers (contractors, consultants) in building waste knowledge in South Africa.

The opportunities to learn from the experience of others, include (i) mentoring by skilled, experienced senior colleagues (often with more than 15 or 20 years practical waste experience), evident in private waste companies (Respondent 5, 11, 22, 37) and municipalities (Respondent 2, 14, 15, 26); (ii) working with contractors operating municipal and private industry landfill sites (Respondent 13, 31); (iii) engaging with consultants contracted by the municipality (Respondent 28) or on retainer to the private company (Respondent 29); (iv) access to equipment suppliers who train local staff and send technical updates (Respondent 30); and finally (v) the establishment of country-to-country city twinning programmes where local municipal officials have access to skilled international waste professionals (Respondent 18, 28).

The importance of learning from experienced senior colleagues is evident in these statements by municipal and private respondents: *‘I was trained and educated by an individual with 25 years of landfilling experience. That was a huge advantage’* (Respondent 26). *“The technical supervisor [on-site] was an environmental engineer. She was quite knowledgeable with waste. So I had someone to guide me”* (Respondent 37).

However, access to experienced colleagues within municipalities is becoming an issue. First, there is a sense amongst older, usually white waste officials, who have been with the municipality (often for more than 15, 20 years) that young staff, often black and often in more senior positions in the waste department, are not interested in drawing on their knowledge:

“I’m 30 years in municipal services and for the past 25 years I’ve been in waste. I’ve been in charge of waste. It’s difficult, because [new managers] won’t take note of what you say, because they’ve got their own agendas. You see things are going wrong, you waste your time to say listen look at that. They said no, you’re interfering. They don’t

want to take advice from a white man, even technically, because then they feel that they're incompetent" (Respondent 6).

Second, experienced waste officials in municipalities are being head-hunted by private waste companies who see the value of their experience (Respondent 15) and who also recognise the potential business opportunities created by removing experienced personnel from the municipality (Respondent 18):

"If they can head hunt all the top guys or the experience in the municipality, they can hire it back at a cost to the municipality. So, of course it makes very good business sense, in that you're creating a gap which they then can take. I mean if you take everything away from the municipality they have to use you, there's no other choice" (Respondent 18).

Neither of these issues would be problematic if municipalities were developing new experienced waste officials that reflect the demography of the country. However, this does not seem to be the case from those respondents interviewed as shown in the results below. First, with 57.1% of black municipal respondents having been in their current job for less than 2 years and 71.4% less than 4 years (Table 4), the data reflect a very mobile young, black workforce in the waste sector.

Second, there is a sense that young professionals are not interested in making a career in waste management, and certainly not in the municipal waste sector:

"I want somebody young to come in so I can train him. I've got 12 years left, so what is going to happen after 12 years, who is going to take it over? There's nobody, it seems like the youngsters that come in, they just want to gain that experience for a year or two and jump to the next path in their career. That's all, they don't want to do it as a fixed [job]. They're really not into waste themselves, it seems like it's something they don't want to do" (Respondent 15).

4.3 Responding to the current levels of waste knowledge

Illeris (2009) points out that education and skills, both at the individual and company level, are very valuable in today's global economy and knowledge society. It is evident that the private waste sector recognises the importance of knowledge in giving them an advantage over their competitors. This is evident from the extent to which senior, experienced municipal waste officials are head-hunted by the private sector and in the measures that have been put in place within waste companies, as highlighted below.

From the results, there are indications that the South African waste sector has moved towards a type of social learning. This is consistent with widely supported modern social learning theories, which posit that people learn from each other through observation, imitation and sharing of knowledge (Scardamalia & Bereiter, 2003). Illeris (2009) recognised that learning is subject to an interaction between the person and their external social and cultural environment. In the near absence of (or access to) formal waste training programmes in South Africa, i.e. theory, some respondents have found innovative ways of social learning. Respondents in municipalities report that they have sought out mentors, where they do not formally exist within the municipality, in the form of knowledgeable consultants or site contractors. Municipalities have, in rare instances, put twinning programmes in place with international cities, where knowledge and best practice is shared and practical implementation projects showcased to municipal officials and councillors. Private companies have put technical managers, or mentors in place, whose responsibility it is to regularly share current local and international best practice in their field with colleagues (Respondent 22, 37); or internal organisational environmental conferences, where employees tasked with environmental and waste management can share problems and jointly seek solutions (Respondent 20, 23):

“Since we’re a national company, we get our national meetings where we get [together] with other people in the same level and we share experiences. Those sessions are very informative and very helpful, because if you were alone and you sit with this kind of situation, it could get too much. But having those sessions where you share and... there’s also lots of resources available for you to get information” (Respondent 23).

With experience being the most significant component of building waste knowledge, respondents reported that the role of mentors is crucial in personal development: *“I think proper mentoring from the supervisor. I’ve been working under my supervisor’s guidance for 8 years. I’ve learnt a lot from him, he’s a specialist in terms of waste”* (Respondent 11). However, there is evidence of differences between public and private respondents regarding their opinions of senior colleagues as mentors. While the respondent from a private waste company recognises the opportunity in senior colleagues: *“I look at the people above me as mentors, people that I try to emulate myself to and use them as examples”* (Respondent 8), one of a few municipal respondents is totally disillusioned by those he needs to report to: *“Our manager he’s been suspended for a month because of corruption”* (Respondent 6).

4.4 Data use within organisations

Analysis of respondents’ answers to the question: *“Was your organisation collecting waste data before it was required for SAWIS, and if yes, for what reason were you collecting data?”* shows that a high proportion (84.6%) of the organisations interviewed were already collecting waste data prior to

the introduction of SAWIS. Financial performance and environmental reporting were seen to be the main drivers for data collection in private organisations, two factors essential in private business (Godfrey & Scott, 2011).

In analysing the data, it is evident that there are distinct differences in waste data use between municipalities, private industry, and private waste companies. As such, the responses have been coded and categorised per organisational type (**Figures 4-6**). The results show that organisations use data on waste management in diverse ways that often reflect the waste discourses of the three organisation types (**Figures 4-6**). This is an improvement on the 2006 study where it was shown that public and private respondents had limited understanding of the potential uses of waste data within their organisations (Godfrey & Scott, 2011). The main uses of the waste data reported in 2006 were at a general level and included: vehicle management, facility planning, costing and site operation (Godfrey & Scott, 2011). Respondents in 2011 show a much greater understanding of, and insight into, the uses and benefits of waste data within the organisation, as reflected in the category trees (**Figures 4-6**).

Municipalities (**Figure 4**) use their waste data mainly for planning and strategic purposes (25% of responses) and for financial management (25%). Private industry uses its data for reporting (28%) and for tracking of waste (managing liability) (17%) (**Figure 5**); while private waste companies predominantly use their waste data for operational (40%) and financial management (37%) (**Figure 6**).

5. Conclusions

Godfrey & Scott (2011) showed that in terms building new knowledge, certain persons interviewed in 2006 had assimilated and interpreted the waste data collected for SAWIS, and that this had raised their awareness regarding vehicle management; facility planning, costing of operations, and ongoing site operation and maintenance. Furthermore, certain persons seeing the value of the data that had been collected used the resultant knowledge, which had a favourable impact on the organisation's waste management operations. On the other hand, there were organizations that did not use the data after having collected it. Either they did not recognise its value, or they had a poor understanding of its potential usefulness. For these organisations data collection had little or no impact on their waste operations. While the preliminary theoretical framework of learning provided a means for interpreting the interview findings, the results showed that knowledge is a necessary but insufficient condition for resultant action.

These conclusions formed the basis for study reported on here, which builds upon the initial preliminary theoretical framework by exploring the relationship between data and resultant waste behaviour. This research is presented in two parts, with this paper focussing on the relationships between the three constructs of knowledge; data, theory, and experience, and waste knowledge. Given the small population size of organisations reporting data to SAWIS, the use of both quantitative and qualitative data, and methods of analysis, have provided a rich picture of the role of waste data in building waste knowledge in South Africa.

The structural model shows that experience has the greatest influence on building waste knowledge in South Africa, nearly twice that of information and three times that of theory. Together the three variables (data, theory and experience) account for 54.1% of the variance in knowledge.

Municipal and private waste organisations are shown to represent two distinct sub-groups in the data set, subject to significantly different influences, impulses and behaviours. The local models reflect a statistically significant difference between these two sub-groups. For the *Municipal* local model, the three constructs account for 49.5% of the variance in knowledge. Theory and information are seen to be the dominant means of building knowledge in municipal respondents, three times greater than experience, while experience is still seen to be the dominant means of knowledge building for private respondents. For the *Private* local model, the three constructs account for 77.9% of the variance in knowledge. The *Private* local model is in alignment with the global model, highlighting the impact of a dominant local model on the overall structural model. The large difference in the contribution of the three constructs to building knowledge for the municipal (49.5%) and private (77.9%) sub-groups, measured for the same population at approximately the same time, suggest that there are strong external influences at play in how municipal and private respondents build their knowledge.

The main findings of the statistical analysis are corroborated by the qualitative data. A content analysis of responses to the open question on the means of learning shows that 67.7% of all respondents report experience as the principle means of building waste knowledge, with 25.8% of responses noting theory and 6.5% of responses selecting data as a means of building waste knowledge. While theory and data are shown to have less significance in building knowledge in both the quantitative and qualitative data, their order of significance differs between the methods of analysis, with the qualitative data providing narratives that illustrates a greater influence of theory than data. While experience remains the dominant means of learning for both private (73.7%) and municipal (58.3%) respondents, theory has a greater influence for municipal respondents (33.3%) than private (21.1%). Data plays a minor role in building knowledge for both municipal (8.3%) and private respondents (5.3%). Given the minor influences of data and theory, combined with the small population size and even smaller sub-population, caution should be applied in the interpretation of the

statistical results of the local models. What remains clear though, from both methods of analysis, is the dominant role of experience in building waste knowledge in South Africa.

While statistically, waste data is shown to have a minor influence on building knowledge, respondents explained that collecting waste data does have a positive impact on the way their organisations manage their waste. However, according to respondents, it is not the waste data that causes the operational response in organisations. This suggests that it is the resultant knowledge, rather than data directly, that influences action.

Out of necessity, the South African waste sector has adopted a form of social learning, where knowledge is socially constructed. In the near absence of (or access to) formal waste training programmes (theory), some respondents have found innovative ways of social learning. Learning from others is shown to be the dominant form of experiential learning, where consultants, site contractors, suppliers and experienced colleagues play a major role in building local waste knowledge.

Category trees, portraying the use of waste data in 2011, show a much greater understanding and insight into the uses and benefits of waste data within the organisations in 2011 than in 2006. As with the building of knowledge, organisational differences are evident in the use of waste data. Municipalities show an emphasis on data use for waste planning and strategy, and financial management. Private industry shows an emphasis on data use for reporting and tracking of waste; while private waste companies predominantly use their waste data for operations and financial management.

Miller & Morris (1999) suggest that without any one of the three constructs, knowledge is not created. While data/information and theory are currently shown from both the quantitative and qualitative data to have minor influences in building waste knowledge in public and private institutions, waste knowledge is being created. What the results cannot show is the quality of this knowledge. This is something that must be explored in future, to gauge whether differences in quality and depth of knowledge occur between organisation types in South Africa.

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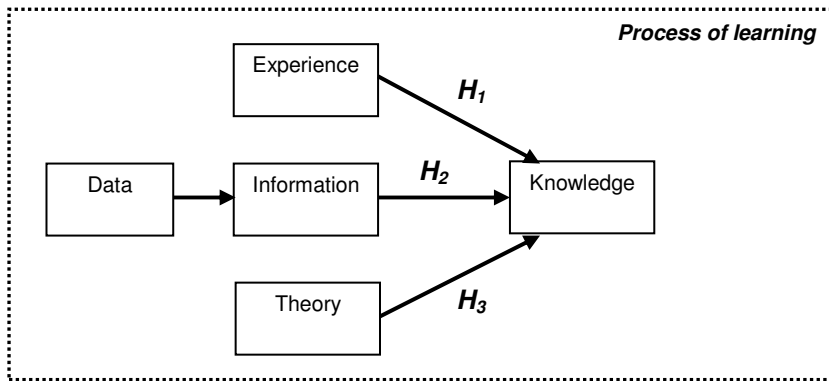


Figure 1. Theoretical framework of learning

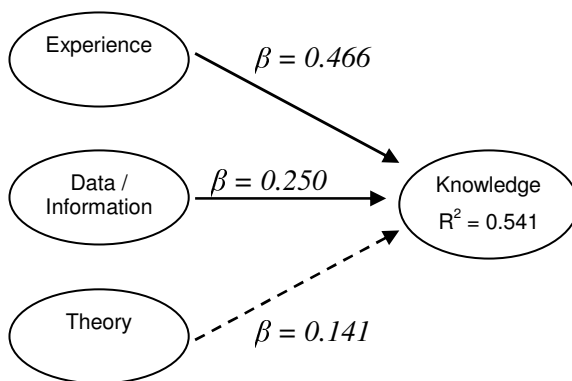
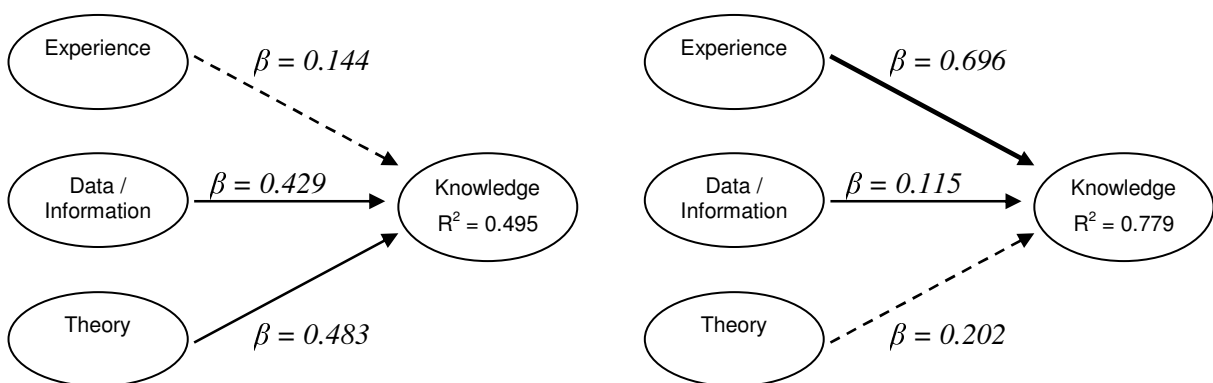


Figure 2. Path diagram for the global model



(a) Municipal local model

(b) Private local model

Figure 3. Path diagrams for the local models (municipal and private)

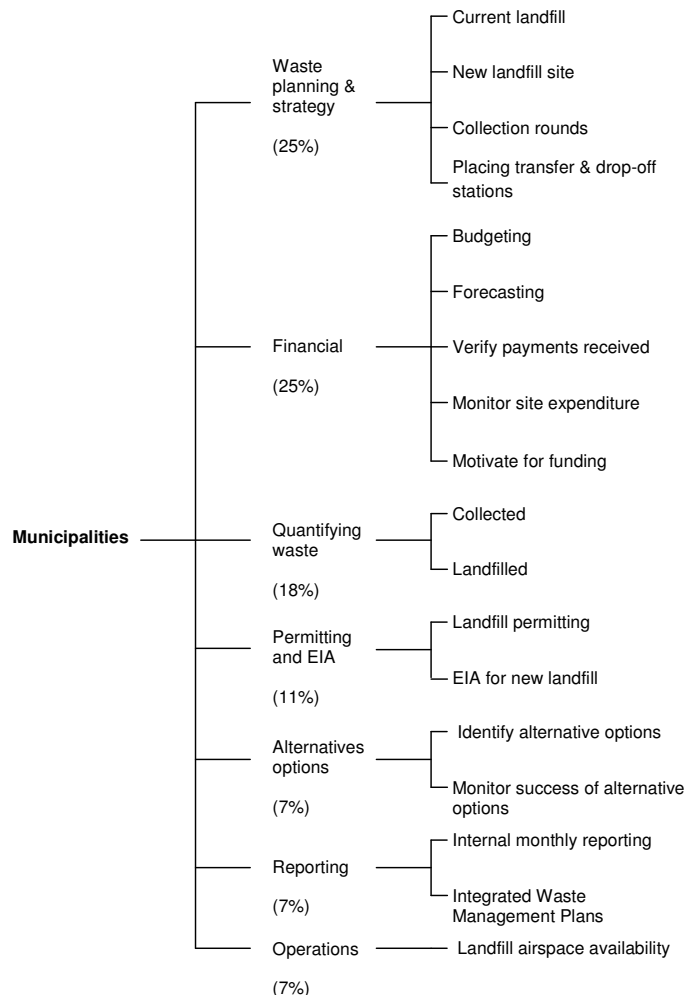


Figure 4 Waste data use by municipalities

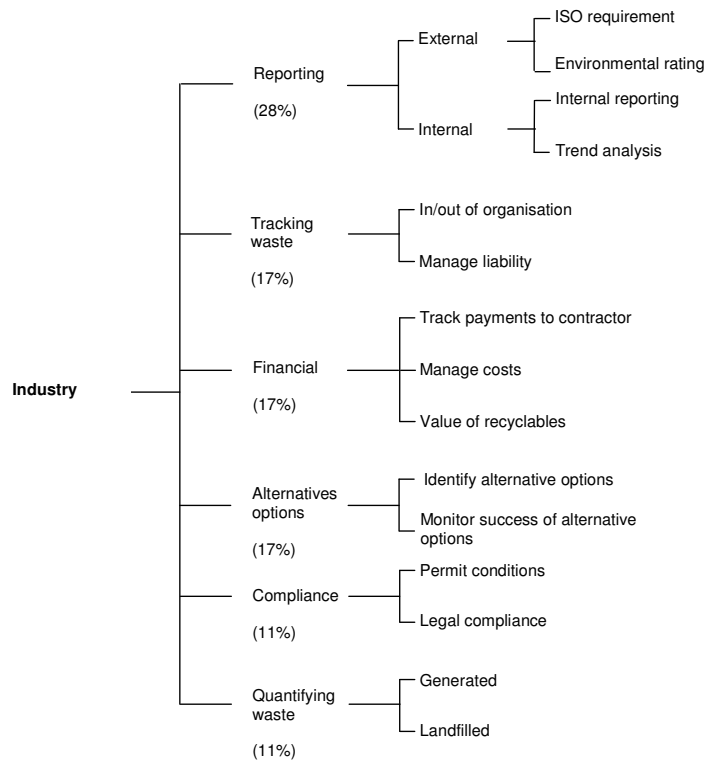


Figure 5 Waste data use by private industry

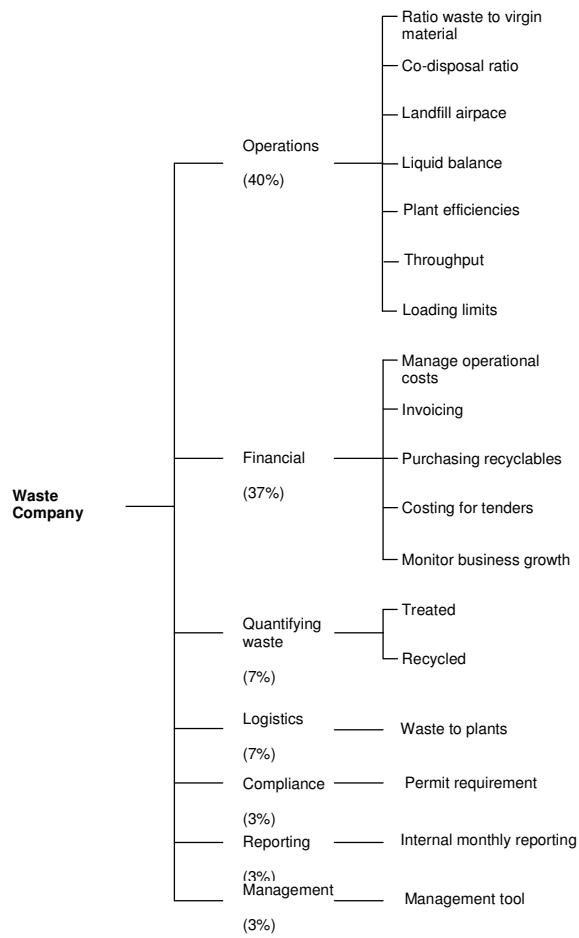


Figure 6 Waste data use by private waste companies

Table 1. Number of organisations reporting data to SAWIS in 2009 and 2010

Reporting year	Reporting organisations ^{*)} (n=)
2009	34
2010	38

Table 2. Number of waste activities reporting data to SAWIS in 2009 and 2010

Activity type	Activities (n=)	
	2009	2010
Landfills	28	29
Treatment Facilities	8	9
Reprocessors	7	8
Total	43	46

*) 39 activities reported to SAWIS in both 2009 and 2010, four activities for 2009 only and seven activities in 2010 only, giving 50 unique activities.

Table 3. Summary statistics and quality indices for the Partial Least Squares Path Model

LV (ξ)	Summary of Inner Model			Reliability / Dimensionality			
	LV-type	MVs	Av.C	α	ρ	Eig.1st	Eig.2nd
Data/information	Exogen.R	2	0.8428	0.816	0.916	1.689	0.311
Theory	Exogen.R	2	0.8736	0.862	0.935	1.757	0.243
Experience	Exogen.R	2	0.6704	0.530	0.810	1.360	0.640

Abbreviations: LV = latent variable/construct; MV = measurement variable; MVs give the number of MVs (items/indicators/measurement-variables) in the construct/LV; Av.C is the average communality (communality index) and is the same as the average variance extracted (AVE, not shown separately); α is Cronbach's alpha (standardized); ρ is Dillon-Goldstein's (or Jöreskog's) rho (aka composite reliability); Eig.1st/Eig.2nd are the first and second eigenvalues from a principal component analysis of the standardized manifest variables (*i.e.* items/indicators of the construct).

Table 4. Years spent in current job (public and private sector) according to race

		Years in current job			
		<2	2-4	4-8	>8
Municipal	Black	57.1%	14.3%	14.3%	14.3%
	White	0.0%	14.3%	42.9%	42.9%
Private	Black	66.7%	22.2%	11.1%	0.0%
	White	45.0%	10.0%	25.0%	20.0%

Note: Presenting the results according to race is necessary to highlight the social inequalities in the societal context in which waste information is being analysed.