# 1     SURVEY RESULTS

## 1.1     Introduction

The end-user survey ran from 22/03/2018 until 06/04/2018 and was conducted using the SurveyGizmo online tool. In total 61 end-users responded to the survey, of which 58 entries were complete and 3 were partial submissions.

As a test population, three (partial) departments were selected. From the Logistics and Procurement departments smaller entities were asked to participate. The Finance department was polled in general.

As participants of the Logistics department, the subdivisions TF OS Business Process; TF LFO PI Mechatronics & Layout; TF LFO PI Optics, Measurement & SQ and TF NXT Continuous Improvement were asked to fill in the survey. Of the 14 people asked to participate, 10 replied, resulting in a very high response rate of 71.4%. The missing 25% were people added in the original survey request that were either out of service, but still listed in SharePoint as employee, or not yet employed, but already created in SharePoint. The end-users out of employment were mainly external consultants who worked project-based in the various departments.
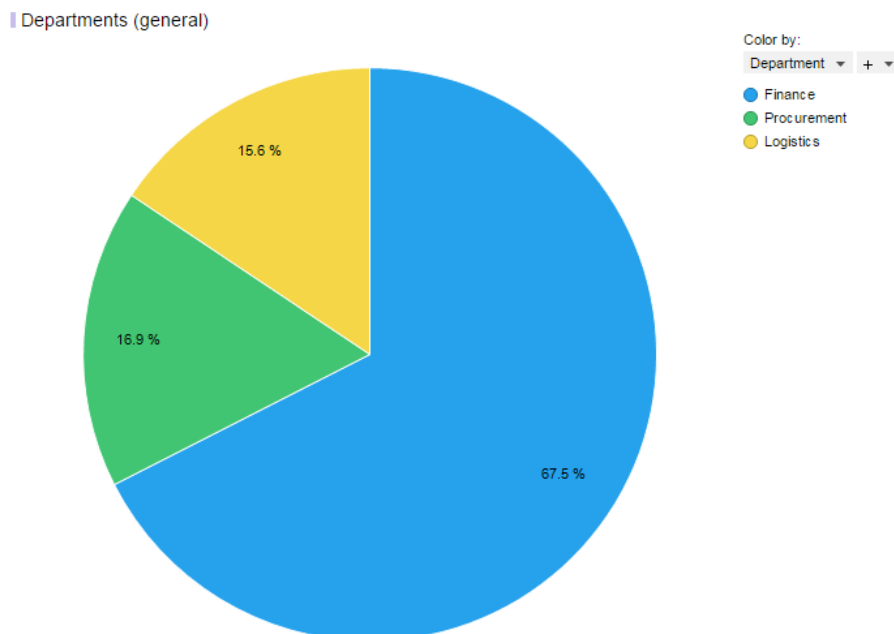


*Figure 7-1: Responses divided over the various departments*

As subdivision of the Procurement department, the business unit SU Analytics & Business Support was selected. Based on a SharePoint employee count for this department, 16 users were sent a message asking them to participate. 8 end-users submitted a response on the survey resulting in a 50% response rate. However

after consulting the head of department before sending a friendly reminder, it appeared the department only had 10 employees listed, boosting the response rate to 80%.

Since there was no list of BI users for the Finance department, the entire department was sent an email asking to fill in the survey. An extra addendum was added to the message stating that this survey was only for the users of business intelligence tools, both expert and end-users. In total 43 submissions were received from the Finance department for 594 emails sent. A lot of those emails were sent to non-BI users and the exact ratio of BI-users versus non-BI users is unknown, any attempt for analyzing the response rate is therefore pointless.

All results were downloaded from the SurveyGizmo website as a .csv file and imported in Excel. In Excel several steps were taken to clean the data and to shape the rough data to a usable data source. These steps included the conversion of the Likert scale text values to numeric values in order to be able to use these values in calculations. Also the values of the multi-select box (for the BI-tools used question) were summarized as a single count column, since these values were spread over multiple columns in the original .csv file. Finally two columns were added in the main data spreadsheet. One was meant for the general department the subdivisions belonged to, i.e. Procurement or Logistics. The other column was for calculating the amount of tools a single user used, based on the multiple columns mentioned above.

The resulting Excel workbook was then imported in TIBCO Spotfire and eight dashboards were created based on the results of this survey. In the chapters below, the results will be discussed in detail.

## 1.2    Departments & usage

In the first dashboard general questions are answered concerning the used BI tools and possible other tools people use to manipulate or visualize data.
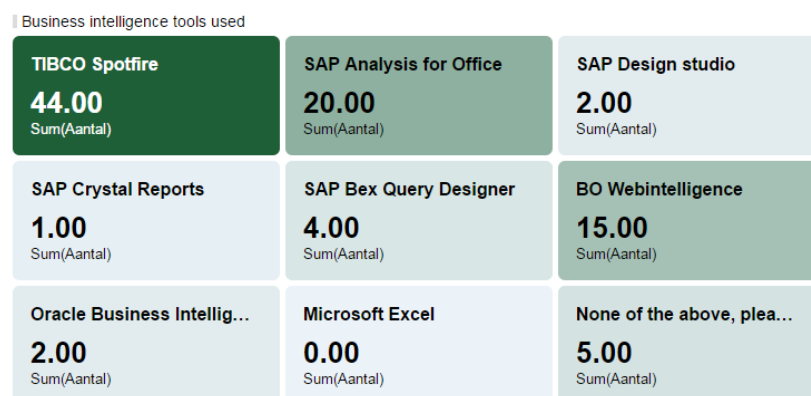


| Business intelligence tools used | | |
|---|---|---|
| **TIBCO Spotfire** 44.00 Sum(Aantal) | **SAP Analysis for Office** 20.00 Sum(Aantal) | **SAP Design studio** 2.00 Sum(Aantal) |
| **SAP Crystal Reports** 1.00 Sum(Aantal) | **SAP Bex Query Designer** 4.00 Sum(Aantal) | **BO Webintelligence** 15.00 Sum(Aantal) |
| **Oracle Business Intellig...** 2.00 Sum(Aantal) | **Microsoft Excel** 0.00 Sum(Aantal) | **None of the above, plea...** 5.00 Sum(Aantal) |

*Figure 7-2: Usage of BI tools according to surveyed end-users.*

On the question "What business intelligence tool do you use", 44 respondents replied they used Spotfire. This means with 72%, Spotfire is the most used BI tool according to the respondents. Next Analysis for Office (20 mentions or 32%) and BO Web intelligence (15 mentions or 25%) came second and third. The other available options were sporadically picked, but seem to be either used occasionally or for specialist reporting.

Since it's possible people use more than one tool for visualizing or analyzing data, the interviewees could select more than one answer to the question "What business intelligence tool do you use". Below is a breakdown of the amount of tools used according to the submitted responses. In general people use only one tool in their daily job. With 34 of 61 answers, this represents a population of 56%. 17 people (28%) say they use 2 tools on a regular basis and 7 people (11%) use 3 or more tools.
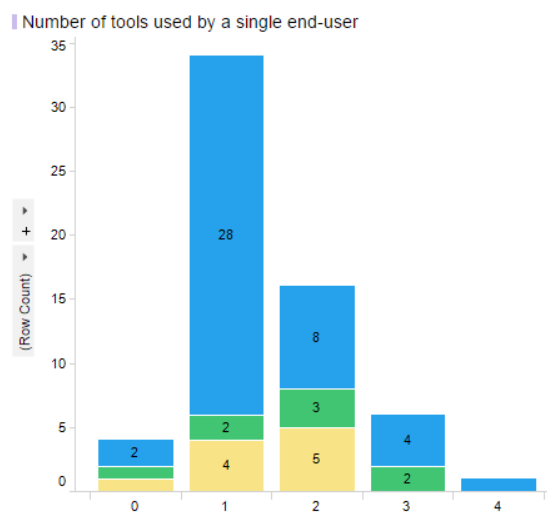


Figure 7-3: Amount of BI tools used by the end-users. Blue is Finance, green is Procurement and yellow is Logistics
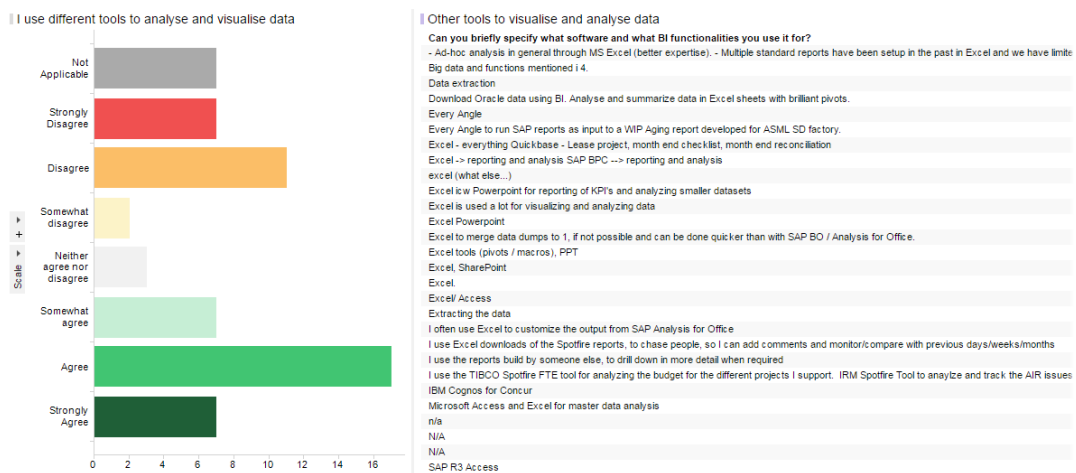


Figure 7-4: Graph showing the agreement to the statement if people use different tools to analyze and visualize data, with a (partial) list of open question responses about what tools they use and what for.

Almost all the end-users that use two tools use Spotfire combined with SAP Analysis for Office. The latter is used for gathering and manipulating data to a usable standard, while the first one is used for visualizing the end result. The people that use three or more tools use them for very specific tasks proper to their job content.

When asked if people used any other tools to analyze and visualize data then the ones stated in the question above, 31 respondents (51%) agreed to the statement, while 20 people (37%) disagreed. 10 answers had either no opinion concerning the statement or found the statement not applicable to their situation. When asked to specify the tools they used, Excel was an often recurring answer, although it was not picked in the first question when asked what BI tools people use. The software is predominantly used to extract and shape data to specific needs or to visualize smaller datasets. It was also mentioned that Excel is used due to having a better expertise in using the software. Every Angle for SAP was also mentioned twice to run SAP reports.

This page teaches that, although all the interviewees use one or more BI tools, a lot of other tools are still used to business intelligence-like processes. Spotfire is the most used package, followed by SAP Analysis for Office and BO Web Intelligence. Other tools are used on a situational basis.

## 1.3 User well-being

This dashboard revolves around the perceived ease of use and perceived usefulness the respondent has towards using the provided business intelligence solutions.
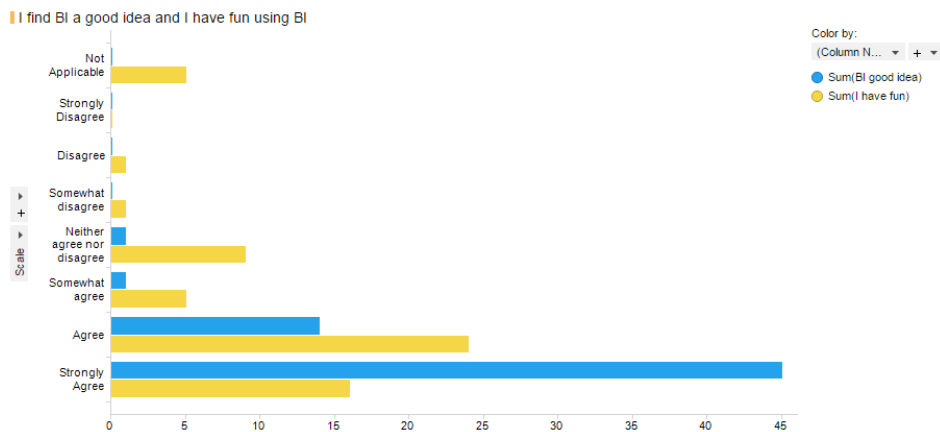


*Figure 7-5: Using business intelligence is a good idea versus I have fun using business intelligence.*

To capture the end-users inclination towards business intelligence in general the straightforward question "Using business intelligence in general is a good idea" was added to the survey. Linked to that statement, a second question was included in

order to try and grasp the sentiments towards the end-user user experience, "I have fun using business intelligence applications".

When combining the results of these two statements, it shows that the vast majority of the respondents acknowledge the importance of using BI in general. 45 of 61 (74%) replied with 'Strongly Agree', while 14 people (23%) replied 'Agree'. There were no negative responses to this statement.

The second statement, concerning the enjoyment of end-users using BI tools, gives a more varied impression. When asked if people have fun using business intelligence software, the majority of the responses can be considered positive, meaning 45 out 61 (74%) were to some extent in agreement with the statement. It's striking though that 9 responses had no opinion on the statement, 2 replies disagreed and 5 deemed the question not applicable to their situation. This means that, not withholding the 5 N/A answers, 18% of the respondents have no degree of gratification in using a business intelligence tool.

To have a more in depth look in the perceived ease of use end-users experience, two questions were asked that were each other's opposite, meaning "I find it easy to use a business intelligence tool" and "I find it difficult to use a business intelligence tool".
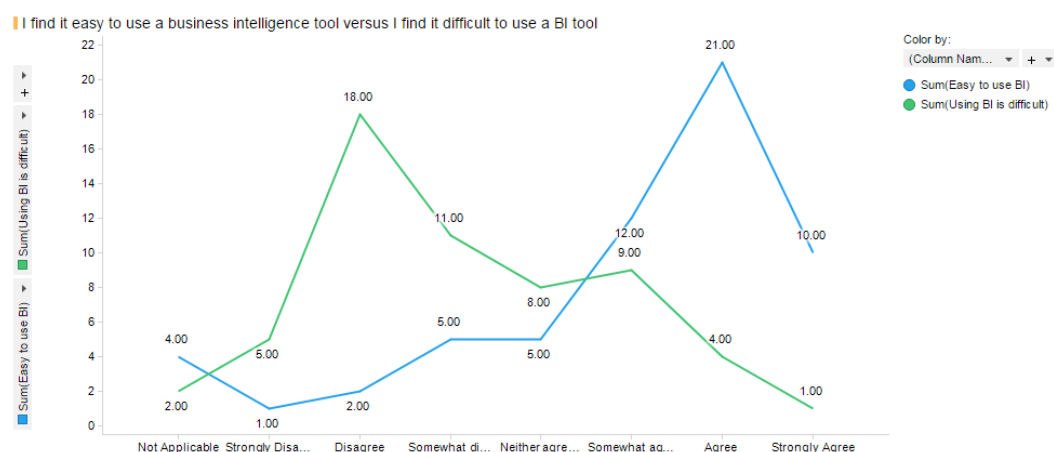


*Figure 7-6: Graph depicting I find it easy to use a BI tool versus I find it difficult to use a BI tool*

The resulting graphs seem each other's mirror image, given slight variances in the responses. While 70% agrees to the statement that BI tools are easy to use and 21% disagrees, 69% of the users disagrees with the statement BI tools are difficult to use and 23% agrees. These matching results validate both statements and give an accurate view on user sentiment towards the use of business intelligence software.

Linked to perceived ease of use which was queried in the questions mentioned above, is perceived usefulness. To get an impression of the usefulness of the business intelligence tools as perceived by the users, the question "Using a business intelligence tool increases my productivity" was added to the survey. 86% thinks that BI increases their productivity to some extent, only 6% thinks otherwise.
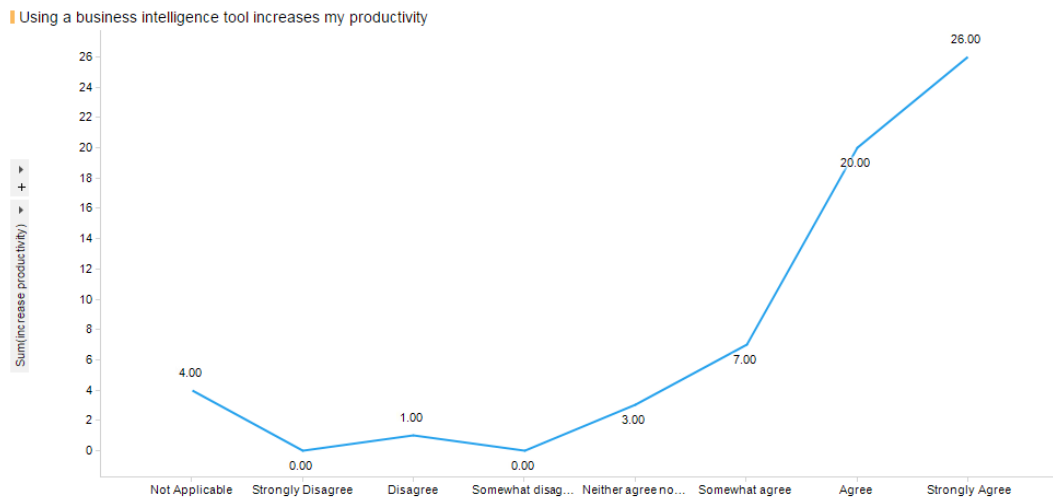
*Figure 7-7: Graph depicting the results of the question "Using a business intelligence tool increases my productivity"*

As mentioned below (chapters 9.1.1 and 9.1.4) management and social pressure have a big influence on the perceived usefulness and business intelligence adoption in general. To capture the extent of the social pressure on the BI users, the survey contained questions how co-workers and managers value the use of business intelligence tools.
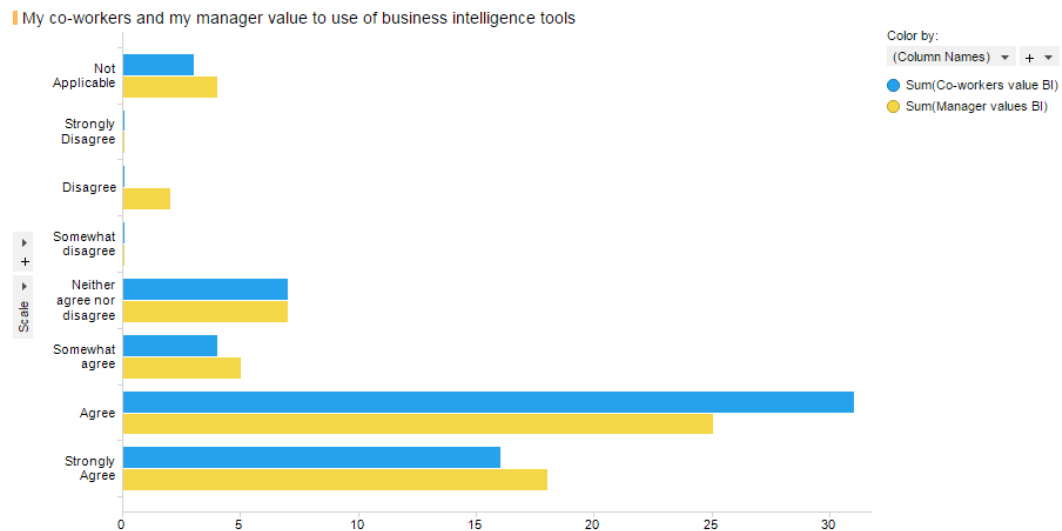


*Figure 7-8: Graph depicting the social pressure on the BI users*

The graph summarizing both questions shows that users find that both their co-workers as well as their management values the use of business intelligence. Only 2 respondents indicated that their manager does not value BI.

This page learns that people understand the importance of using business intelligence software in their daily workflow, but sometimes lack the motivation or

gratification to keep using it. Users however are in agreement that BI improves their productivity and their general surroundings exerts enough social pressure to hopefully motivate them to continue to use BI tools.

## 1.4      Report usage & workflow

This page revolves around the way users use reports and how business intelligence impacts user's workflows. This section involves questions like "Is there data manipulation required" or "Is the manipulation I want to do possible". Also questions about infrastructure or resources and about business or IT owned reports are used in this dashboard.

In general it seems users have enough access to the proper infrastructure in order to work with business intelligence. In this case infrastructure means hardware, software and services provided to BI end-users. There is however a distinct divide when asked if people can connect to the data sources provided by IT. About the same amount of respondents indicate they can or cannot find and connect to IT governed data sources (22 agree (36%) versus 24 disagree (39%)). This can be a big roadblock for pushing the adoption of business intelligence to a higher level, since almost two in five users indicate he or she cannot find the required sources of information.
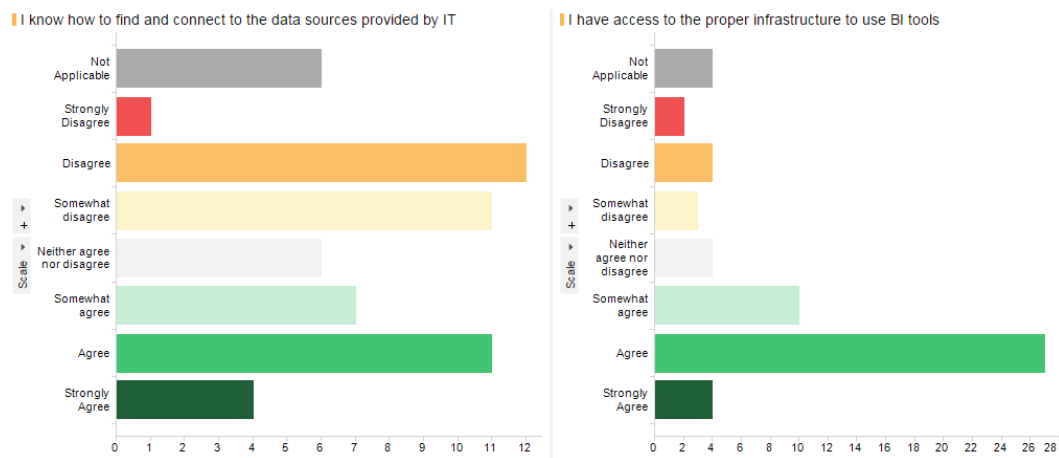


*Figure 7-9: Graph depicting ability to find and connect to data sources on the left and availability of infrastructure on the right*

Although end-users seem to have difficulties finding IT governed data sources, it does not withhold them from creating most of the reports themselves. If asked the question if they use IT provided reports the vast majority indicates to not use these reports at all. Only 20% of the respondents said they used an IT provided report to some extent. Linked to this result, over 74% of the polled users indicated they preferred to make the reports themselves in a business intelligence tool.
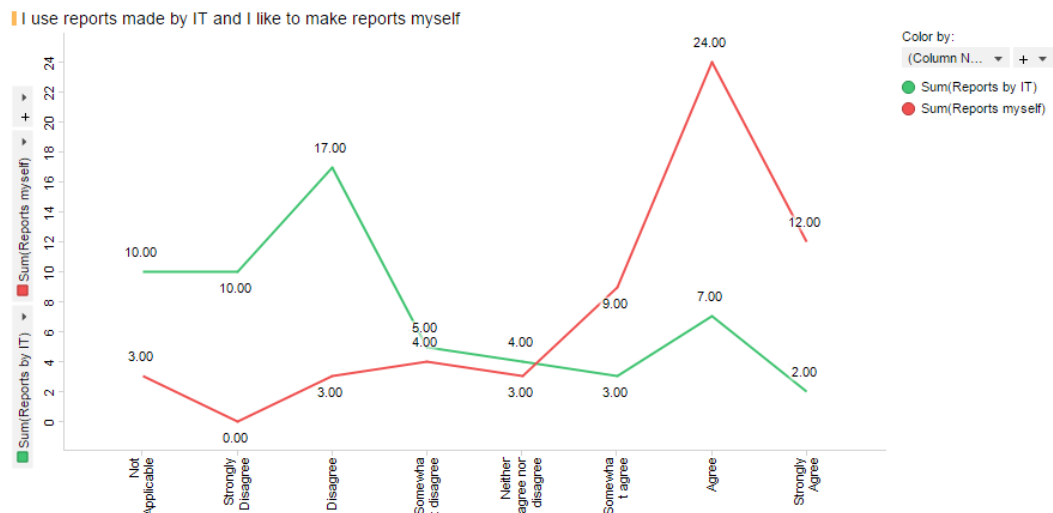
Figure 7-10: Graph summarizing the inclination towards using IT provided reports or making reports themselves

This preference for wanting to create reports themselves could originate from a desire to shape and style reports to end-user needs, but could also result from the need to manipulate the provided data before use. More than 64% of the surveyed users says data manipulation is required before use in a report or dashboard. The only caveat is however that over 27% of user indicates that the data manipulation they require is not possible within the tool they currently use.
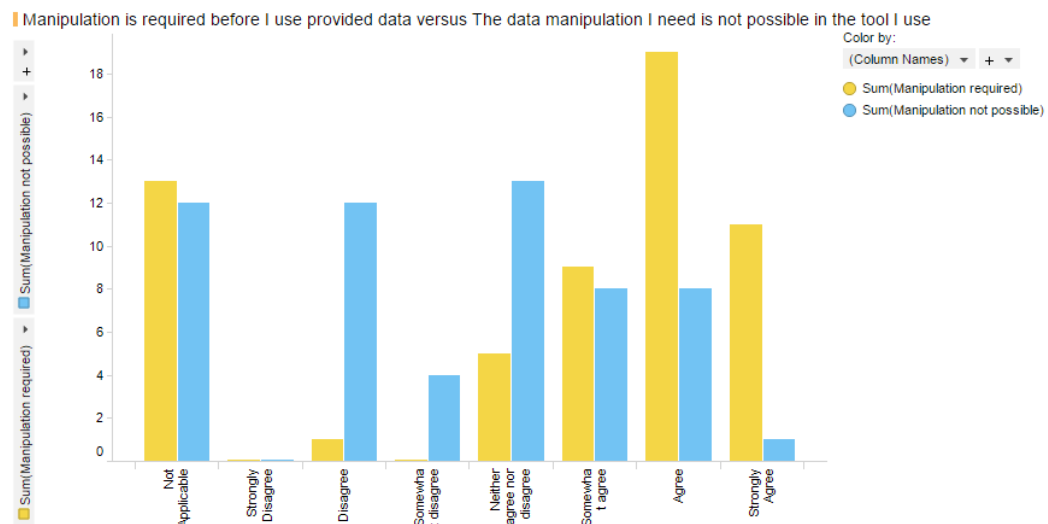


Figure 7-11: Manipulation of data is required before use versus The manipulation I want to do is not possible in the tool I use

The necessity to manipulate data, but the lack of possibility in the provided BI tools could explain why people end up using other tools to shape the data the way they require for further use. It could also be possible the data manipulation is possible in the provided tools, but users are unaware of the fact it is possible or perceive using another tool is easier or faster. Therefore further research is required to discover the reasons behind the results of these questions.
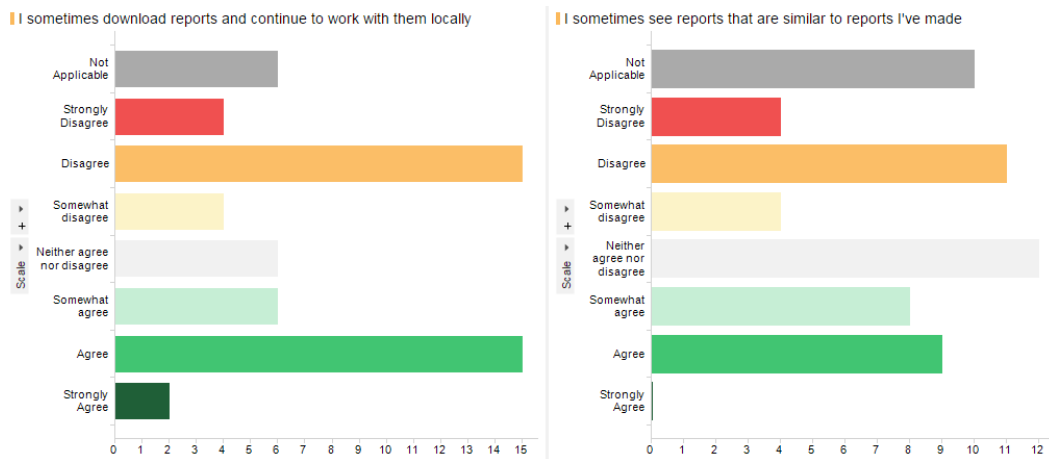
*Figure 7-12: Graphs presenting the results of the questions "I sometimes download reports and continue to work with them locally" on the left and "I sometimes see similar reports to reports I've made" on the right*

Finally users give the indirect message that doing redundant work is present but not as much common practice. On both the question "I sometimes download reports and continue to work with them locally" as on "I sometimes see reports that are similar to reports I've made" respectively 38% and 28% are in agreement to some extent (versus 37% and 31% in disagreement).

Downloading and working with reports locally however facilitates the creation of local silos with outdated data, which possibly compromises the 'single version of the truth' philosophy and could result in incorrect reporting.

Also the existence of similar reports means users have no knowledge of people working on the same content or building the same analyses. It could possibly alleviate user workload if these reports could be shared and reused, possibly over different departments or business units.

This dashboard teaches people have sufficient access to infrastructure in order to use BI solutions, but sometimes are unable to find and connect to the proper data sources (i.e. 'sources of the truth'). People also prefer to make reports themselves instead of using reports provided by the IT department. This could be due to some data manipulation required in order to present the data as required.

Some users indicate though that the manipulation they want to do is not possible in the business intelligence tool they use, which could explain why some people use other software to shape the data source. One of those tools could be Excel, as mentioned above in chapter 7.2. Also it seems some redundant work is done since people indicate they see similar reports passing by and there is also the danger of making mistakes in reports due to local downloads and possible disconnection from the original data source.

## 1.5  BI tool performance

The business intelligence tool performance dashboard tries, as stated, to capture the perceived performance of the tools in question by the different end-users. During the survey, people were asked to specify, considering an average workday, how much time, percentage-wise on a daily basis, they worked with business intelligence software.
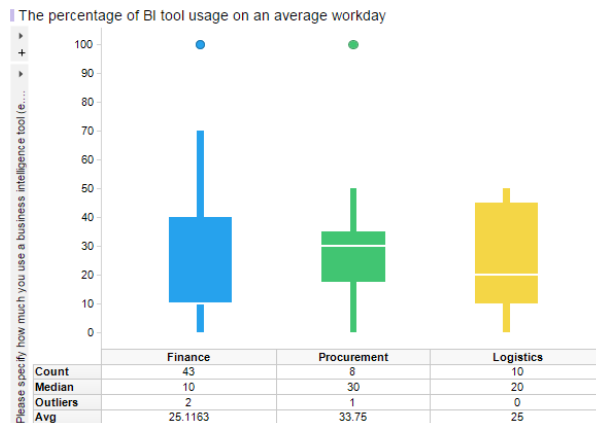


The percentage of BI tool usage on an average workday

| | Finance | Procurement | Logistics |
|---|---|---|---|
| Count | 43 | 8 | 10 |
| Median | 10 | 30 | 20 |
| Outliers | 2 | 1 | 0 |
| Avg | 25.1163 | 33.75 | 25 |

*Figure 7-13: Boxplots showing the division of BI tool use for the different surveyed departments*

In general the majority of the end users seem to use business intelligence software between 0 and 40% of the time on an average workday. The averages across the different departments range between 25 and 33%. Striking is that the median and first quartile in the Finance department is set to 10% indicating that half the polled users in Finance use a BI solution 10% or less on an average workday. On the other hand, this department had two extreme outliers who indicated they used BI 100% of the time and a sample maximum of 70% possibly indicating a workload division between expert report builders and report consumers.

The same situation applies to the sub departments indicated as belonging to the Procurement department. One extreme outlier says he or she uses BI tools 100% of the time, while the rest of the results range between 0 and 50%. The interquartile range is lower in this department though. At 17.5 the dispersion of the results is less spread then in the Finance department where the interquartile range was 30. A median and average of 30 and 33.75 is still somewhat low, possibly indicating that the majority of the respondents in this department are also report users, or only occasional report builders.

The Logistics department does not contain any outliers. The minimum and maximum lies at 0% and 50% with a median of 20% and an average of 25%. These values may indicate people in this department use BI tools on a regular basis as self-service tools to make reports and visualize or analyze data, but no dedicated expert users are present.

When asked if using BI increases job performance, the vast majority of the users is in agreement with this statement. Over 86% sees business intelligence as a positive influence on their job performance. Only 5% disagrees with this statement.
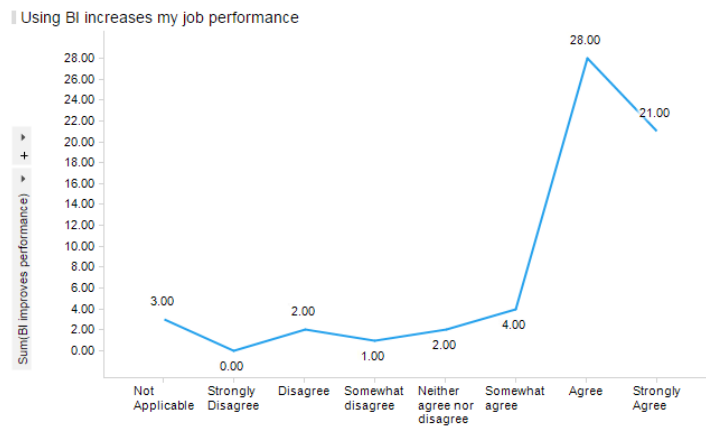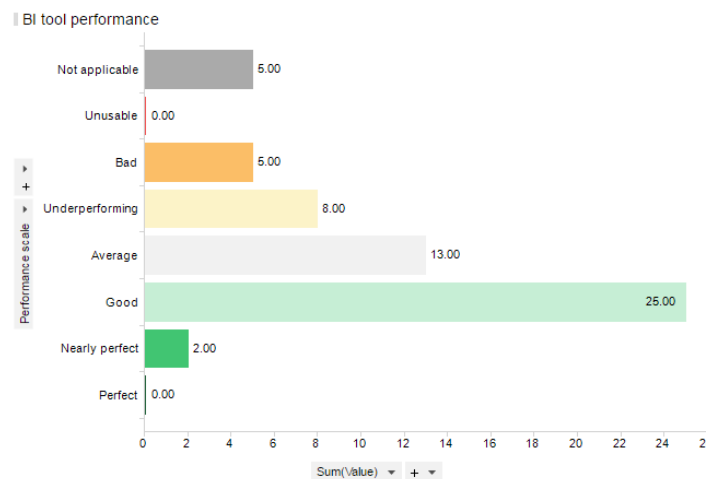


Figure 7-14: Line chart indicating user job performance perception when using BI tools



Figure 7-15: Evaluation of BI tool performance and comments what is going wrong according to the users (abstract)

When asked for the business intelligence tool performance itself, responses are less unanimous. Only 44% of the users indicates the tools merit a good or better evaluation. Almost the same amount of users (42%) evaluates the performance of the provided tools as ranging from average to bad.

The most recurring issues according to the end-users are tool stability or speed and tool knowledge. It seems some of the tools that are provided have high loading times. This could be because reports are linked to numerous data sources with complex queries to perform. Otherwise this could also be a result of the way reports are built. Having a low performance on report construction can result in high loading times due to redundant, inefficient or unnecessary data loads. Indications of bad performance could result in end-users preferring to use other software in their daily job for BI purposes.

Lack of knowledge is also a recurring answer. Users acknowledge their own limitations in using the provided tools, resulting in inefficient or badly designed reports and indirectly to bad performance of the BI tool.

The next recurring remark does not apply to the tools themselves, but to the underlying data sources. It seems people are having issues with overnight reloading sources or bad connections between data sources, which prevents real time reporting. Also the connection speeds to the various data sources seem to vary during the day when different sites of ASML are active/not active.

The design of the data sources is also commented. It seems users have issues with data source complexity and have issues finding the correct data within a single data source. Also it seems users ask for a more granular approach, where different reports can access different parts of a data source, instead of the access to a data source means access to all the data approach that is in place now.

Finally user friendliness of the provided tools, and specifically Spotfire, is a recurring answer as well. People think Spotfire is not user friendly. This however could be due to lack of knowledge or lack of support, which results in users being unable to find answers to questions they have and being unable to make the tool do what they want it to do.
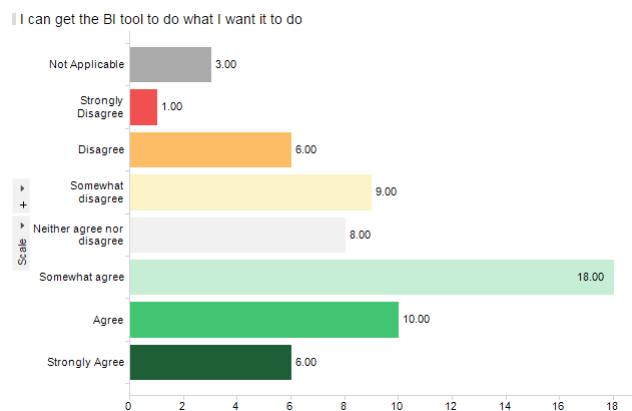


*Figure 7-16: Users indicating if they can make the BI tools do what they want them to do*

The negative evaluation of the user-friendliness of the provided tools also translates in the results to the question "I can get the BI tool to do what I want it to do". One quarter of the polled users indicates they have, to some extent, issues with making the BI tools deliver the results they want. If we however include the undecided replies, this amount increases to nearly 40%. Only 55% of the BI users indicates they have the skills to make the tool, to some extent, provide the result they want.

## 1.6 Training & questions

Having enough training and available help resources is a good incentive to keep using a tool or solution. To get a better understanding about BI training at ASML, some questions were added to the survey that specifically targeted the perceived availability of training and help.
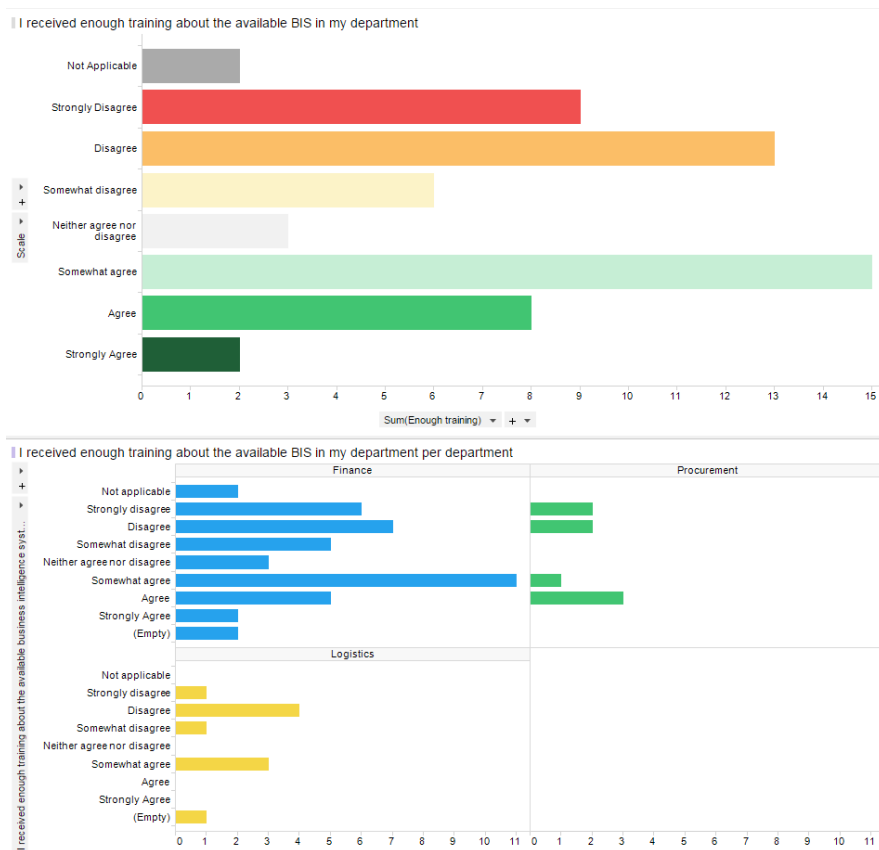


*Figure 7-17: Indication of perceived sufficiency of training level, with a breakdown per department*

When asked if people received enough training about the business intelligence systems in their department, results are not so positive. Only 41% indicates they are to some extent in agreement with the statement, with more than half of these replies only somewhat agreeing to the statement. Just under 46% disagrees with

the statement with more than three quarters of those respondents disagreeing or even strongly disagreeing.

A breakdown of these results per department teaches that the amount of users that agree or disagree are somewhat equally divided in the Finance (16 agree versus 18 disagree) and Procurement (4 agree and 4 disagree) department. In the Logistics department however, the majority of the polled users (6 disagree and 3 agree) feel they are not receiving enough training to use business intelligence tools.

Insufficient knowledge as an issue also surfaced when asked to evaluate the BI tool performance earlier on. Seeing this result confirmed when asked directly about training indicates the presence of a more structural issue.

In preparation to this survey, a status quaestiones was made of the available training material for the various tools that were offered to the end-users. It was noted that almost all the training material comprised of PowerPoint tutorials with in software step-by-step screenshots and DIY exercises with defined written end goals. To verify if users liked these training aids, some questions were added to the survey asking what training aids users liked and where they found help if needed.
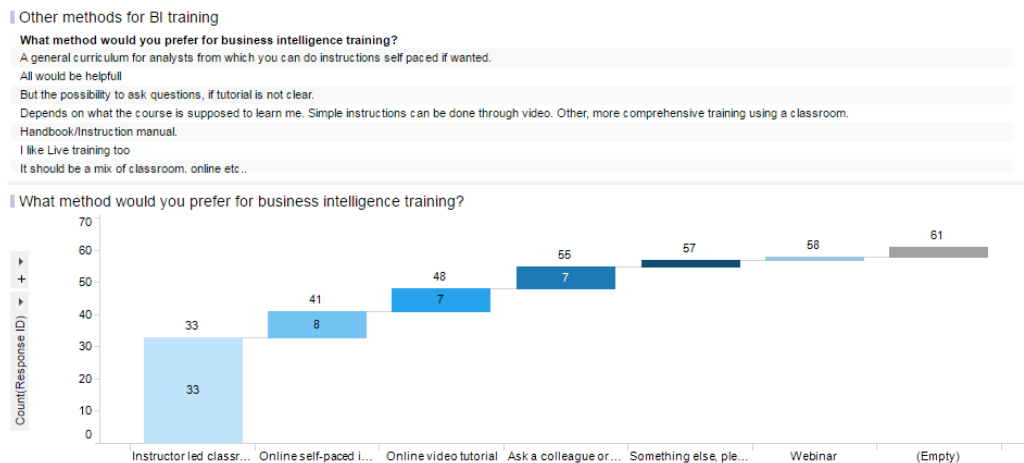


*Figure 7-18: Representation of the answers users submitted to the question about training methods*

Although most of the training material currently available is self-paced static content, it seems the majority of the users still prefers the classic instructor-led classroom (54%). 'Online self-paced instructions' (13%), 'online video tutorials' (11%) and 'ask a colleague or peer to teach you' (11%) are in second and (joint) third place.

Some of the comments concerning the possible training methods indicate that people like instructor led classrooms because they like the ability to directly ask questions. Some people also indicated that they prefer training material should be customized to the various departments where the BI tool is used, since every department has specific requirements and demands to reporting. Given this information this would suggest the current training content at ASML is unfitting for user expectations or requirements and is in need of change.

Paired to the question if the training material was adequate, the question was posed if users were able to find help if needed. Among the options evident choices were included like 'ask a colleague' or 'Google' and less evident but more preferred options were added like 'IT direct chat', 'SharePoint help portal' or 'the Big Data & analytics (BDA) homepage'. Although people seem to be able to find help, 62% agrees to find help if needed while 26% does not agree, users prefer to ask a colleague for help (66%) or browse Google (10%) for an answer. The official channels score terrible with 6% for the BDA website, 5% for the IT direct chat and only 3% for the IT SharePoint help portal.
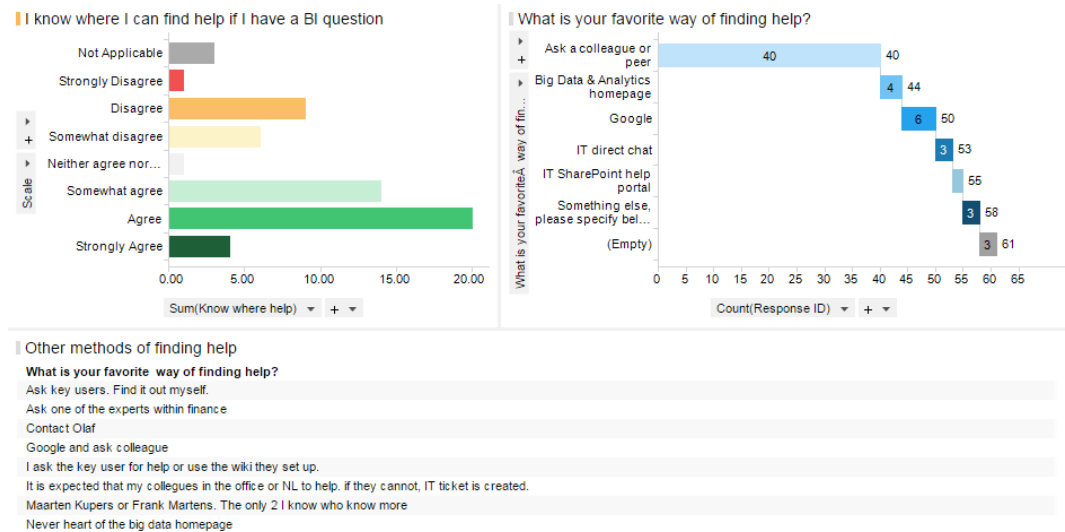


*Figure 7-19: Agreement to the statement if people find help if needed, the sources they find help and possible other methods (abstract)*

It could be that users simply prefer to ask a colleague, who they think knows the answer, for a solution since the threshold to ask someone you know is lower and possibly faster. This does however imply these key users get work added to their workload occasionally. It could however be the case that users don't find the official channels for help. Such a conclusion is backed by one of the comments stating they "never heard of the big data homepage".

Fact is though that a quarter of the respondents indicate they know not where to find help if needed and, as some of the users said in the question "what method would you prefer for BI training", a reference manual, which could remedy some of the issues, is absent for some tools or, when present, can't be found by the users.

## 1.7    End-user intentions

Although people indicate training, and their knowledge of the tools, is an issue, they say they have the knowledge and ability to make use of the provided business intelligence tools. Just under 64% of the users agrees to this statement, while just under 20% disagrees.
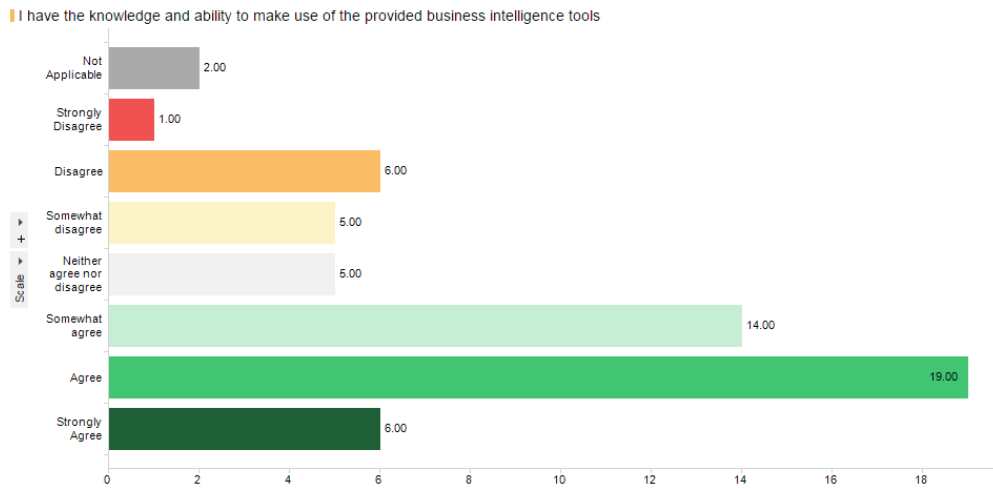
*Figure 7-20: Do you have the knowledge and ability to make use of the provided business intelligence tools?*

This confidence in users own ability combined with the perceived ease of use of the offered BI solutions makes users susceptible to the possibility to change their current workflow in order to use business intelligence solutions more. On the graph below, the graph from the User well-being dashboard is replotted, combined with the results to the question if people would change their workflow.
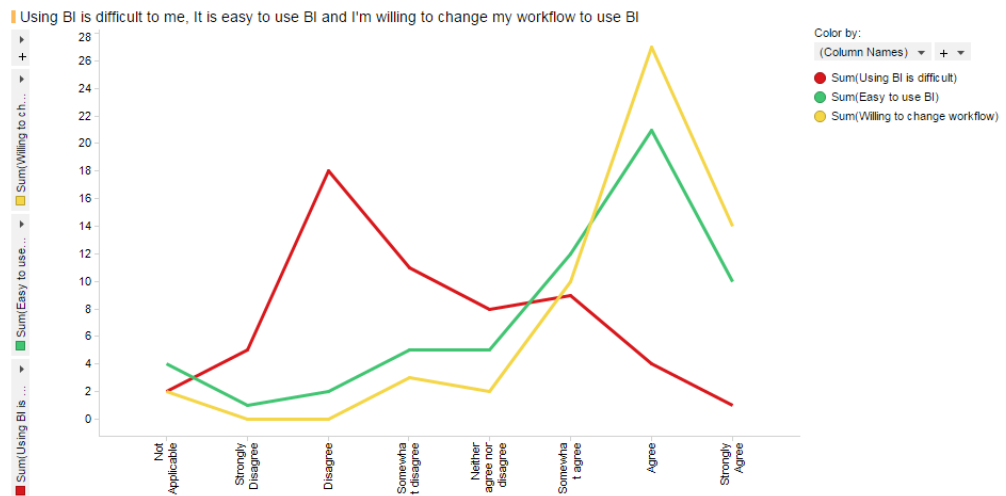


*Figure 7-21: Is BI easy/difficult to use versus I'm willing to change my workflow in order to use BI more*

This graph shows willingness to change closely follows the perceived ease of use, possibly indicating that perceived ease of use influences willingness to change workflow. If the correlation between both graphs is calculated an R-value of 0.42 with an $R^2$-value of 0.18 and a p-value of 0.00103. Since p is below 0.05 the null hypothesis is rejected. Generally in exact science an R-value of 0.6 is required for accepting correlation between variables. However in social science an R-value of 0.2 and even lower is accepted (Abelson, 1985). Therefore it's safe to assume a

correlation exists between perceived ease of use and willingness to change workflow.
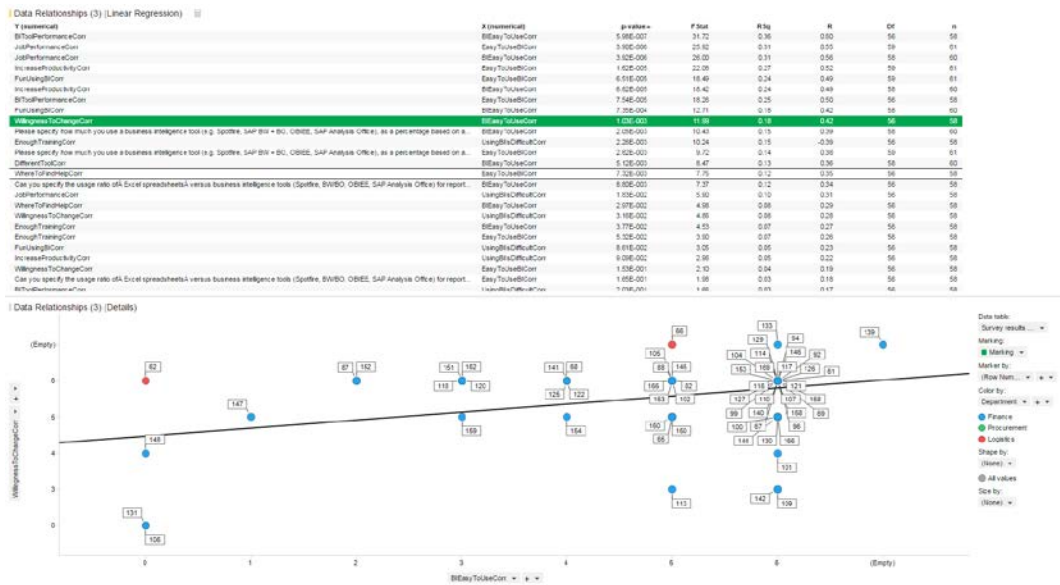


Figure 7-22: Correlation between perceived ease of use and willingness to change workflow



Figure 7-23: Responses to the open question "Considering using BI tools, what would help you most for optimizing your workflow" (extract)

The last question of the survey was a request to indicate what could improve in general for the end-users of business intelligence tools. The question had a multi-line textbox where people could write remarks or suggestions. Among the many suggestions some responses appeared numerous times.

Striking is that the suggestion for more education reappears again. This education does not only mean initial training, but also follow up courses and extended user support, like feedback on reports or troubleshooting. BI tool performance and user

friendliness also seems a hot issue for users. Also data source access and performance gets mentioned several times as well.

One striking remark merits the final mention. One user mentions that in his/her department upper management buy-in is required for utilizing BI tools for reporting, indicating this seems to be lacking or is not expressed clear enough.

## 1.8    Analysis

### 1.8.1    Questions compared to ease of use

Visualizing the survey data in various dashboards already gives an insight in the issues that prevents users from utilizing the provided BI tools to the fullest. It is however possible to try and find correlations in the data, which can indicate the influences one variable has on another.

| Y (numerical) | X (numerical) | p-value ▲ | F Stat | RSq | R | Df | n |
|---|---|---|---|---|---|---|---|
| BIToolPerformanceCorr | BIEasyToUseCorr | 5.98E-007 | 31.72 | 0.36 | 0.60 | 56 | 58 |
| JobPerformanceCorr | EasyToUseBICorr | 3.90E-006 | 25.92 | 0.31 | 0.55 | 59 | 61 |
| JobPerformanceCorr | BIEasyToUseCorr | 3.92E-006 | 26.00 | 0.31 | 0.56 | 58 | 60 |
| IncreaseProductivityCorr | EasyToUseBICorr | 1.62E-005 | 22.06 | 0.27 | 0.52 | 59 | 61 |
| FunUsingBICorr | EasyToUseBICorr | 6.51E-005 | 18.49 | 0.24 | 0.49 | 59 | 61 |
| IncreaseProductivityCorr | BIEasyToUseCorr | 6.82E-005 | 18.42 | 0.24 | 0.49 | 58 | 60 |
| BIToolPerformanceCorr | EasyToUseBICorr | 7.54E-005 | 18.26 | 0.25 | 0.50 | 56 | 58 |
| FunUsingBICorr | BIEasyToUseCorr | 7.35E-004 | 12.71 | 0.18 | 0.42 | 58 | 60 |
| WillingnessToChangeCorr | BIEasyToUseCorr | 1.03E-003 | 11.99 | 0.18 | 0.42 | 56 | 58 |
| Please specify how much you use a busin… | BIEasyToUseCorr | 2.05E-003 | 10.43 | 0.15 | 0.39 | 58 | 60 |
| EnoughTrainingCorr | UsingBIIsDifficultCorr | 2.26E-003 | 10.24 | 0.15 | -0.39 | 56 | 58 |
| Please specify how much you use a busin… | EasyToUseBICorr | 2.82E-003 | 9.72 | 0.14 | 0.38 | 59 | 61 |
| DifferentToolCorr | BIEasyToUseCorr | 5.12E-003 | 8.47 | 0.13 | 0.36 | 58 | 60 |
| WhereToFindHelpCorr | EasyToUseBICorr | 7.32E-003 | 7.75 | 0.12 | 0.35 | 56 | 58 |
| Can you specify the usage ratio ofÄ Excel … | BIEasyToUseCorr | 8.80E-003 | 7.37 | 0.12 | 0.34 | 56 | 58 |
| JobPerformanceCorr | UsingBIIsDifficultCorr | 1.83E-002 | 5.90 | 0.10 | 0.31 | 56 | 58 |
| WhereToFindHelpCorr | BIEasyToUseCorr | 2.97E-002 | 4.98 | 0.08 | 0.29 | 56 | 58 |
| WillingnessToChangeCorr | UsingBIIsDifficultCorr | 3.16E-002 | 4.86 | 0.08 | 0.28 | 56 | 58 |
| EnoughTrainingCorr | BIEasyToUseCorr | 3.77E-002 | 4.53 | 0.07 | 0.27 | 56 | 58 |
| EnoughTrainingCorr | EasyToUseBICorr | 5.32E-002 | 3.90 | 0.07 | 0.26 | 56 | 58 |
| FunUsingBICorr | UsingBIIsDifficultCorr | 8.61E-002 | 3.05 | 0.05 | 0.23 | 56 | 58 |
| IncreaseProductivityCorr | UsingBIIsDifficultCorr | 9.09E-002 | 2.96 | 0.05 | 0.22 | 56 | 58 |
| WillingnessToChangeCorr | EasyToUseBICorr | 1.53E-001 | 2.10 | 0.04 | 0.19 | 56 | 58 |
| Can you specify the usage ratio ofÄ Excel … | EasyToUseBICorr | 1.65E-001 | 1.98 | 0.03 | 0.18 | 56 | 58 |

*Figure 7-24: List of correlation calculations made for several variables related to the three 'perceived ease of use' questions. Questions with a p-value larger than 5E-002 are excluded since the null hypothesis is not rejected*

To begin a number of statements were tested using one base statement which encompassed three questions in the survey. These base questions revolved around the 'perceived ease of use' and were the redundant questions "I believe it's easy to get a business intelligence tool to do what I want it to do" (EBI) and "Overall, I believe a business intelligence tool is easy to use in my job" (BIE) and the opposite question "Using business intelligence tools is difficult for me" (BID).
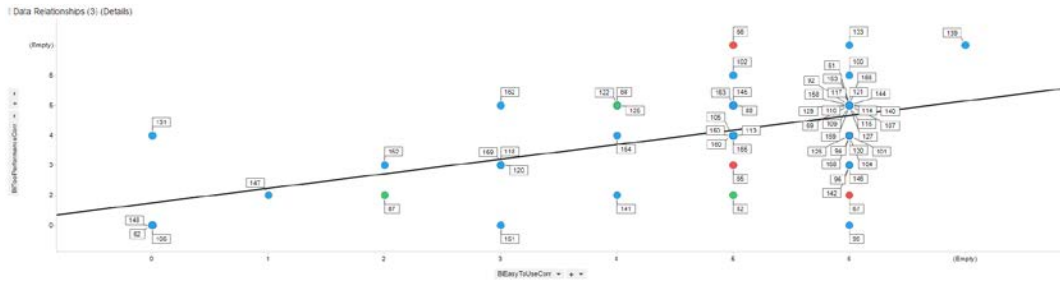
*Figure 7-25: Correlation between BIE and BI increases my job performance*

Several questions were found with a correlation to the perceived ease of use, with R-values ranging from 0.6 to 0.28. The highest correlation could be found between and the BIE question and the statement concerning job performance "At present, I think the performance of the Bi tools is". It seems that people who are convinced that the tools are easy to use rate the performance of the BI tools higher, whereas people struggling with BI software aren't as positive. This could be due to lack of knowledge having an impact on the perceived ease of use. When the question "I received enough training" is compared to the ease of use questions, it seems it's negatively correlated to the BID question.
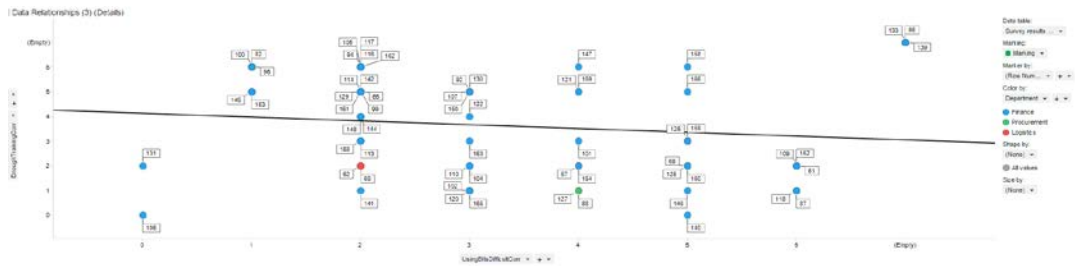


*Figure 7-26: Negative correlation between BID and I received enough training*

With -0.39 the strength of the correlation is less profound than the correlation between the variables of the first question, however it seems people who perceive to struggle with BI solutions indicate they require more training.

Although more training is a hot topic among interviewees, it seems perceived ease of use is also correlated to the perceived job performance (R-value of 0.55), where the majority of the people who indicate ease of use is average at best still evaluate the effect of the BI solution on their job performance as a positive influence.

*Figure 7-27: Positive correlation between ease of use and perceived effect on job performance*

Linked to the effect on job performance, people who find BI easy to use are also more susceptible to change their workflow in order to use BI solutions (R-value of 0.42) and the time they use BI solutions increases as well (R-value of 0.39)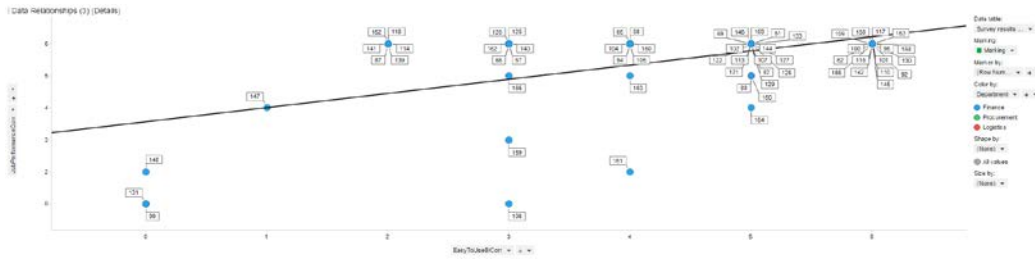. This is also pretty self-explanatory since it possible to assume, that if you think a solution is easy to use, the threshold a user experiences in order to use that solution is lower than when it is not easy to use. The same applies to willingness to change workflow. If a user sees the benefits of a tool, it's easier to implement it in a current workflow, or adapt the workflow in order to use more of the functionalities the tool provides.



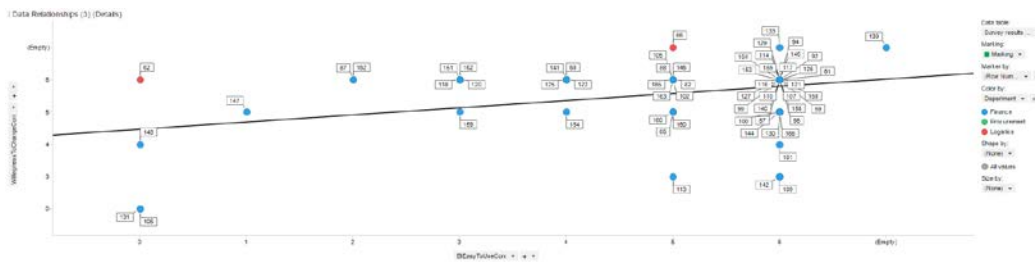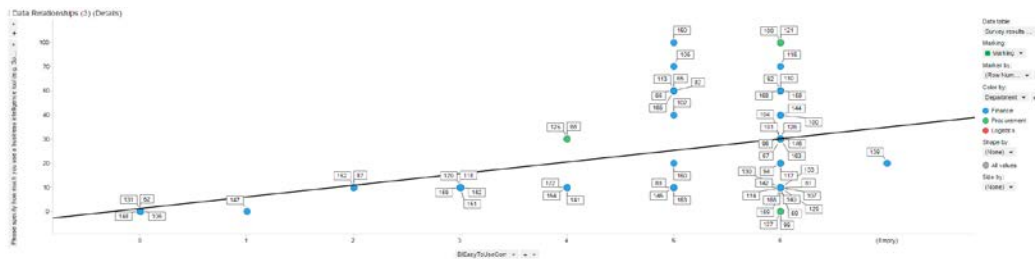*Figure 7-28: Willingness to change workflow and BIE correlation graph*



*Figure 7-29: Correlation between BI tool time used and BIE questions*

## 1.8.2    All questions compared for correlations

The next step is to compare every question to every other question and see what correlations appear. This research method has yielded some pretty evident conclusions, but also some surprising finds.

**Data Relationships (2) (Linear Regression)**

| Y (numerical) | X (numerical) | p-value ▲ | F Stat | RSq ▼ | R | Df | n |
|---|---|---|---|---|---|---|---|
| FunUsingBICorr | IncreaseProductivityCorr | 4.32E-021 | 209.87 | 0.78 | 0.88 | 59 | 61 |
| IncreaseProductivityCorr | FunUsingBICorr | 4.32E-021 | 209.87 | 0.78 | 0.88 | 59 | 61 |
| IncreaseProductivityCorr | JobPerformanceCorr | 1.55E-017 | 145.04 | 0.71 | 0.84 | 59 | 61 |
| JobPerformanceCorr | IncreaseProductivityCorr | 1.55E-017 | 145.04 | 0.71 | 0.84 | 59 | 61 |
| FunUsingBICorr | JobPerformanceCorr | 3.75E-012 | 75.53 | 0.56 | 0.75 | 59 | 61 |
| JobPerformanceCorr | FunUsingBICorr | 3.75E-012 | 75.53 | 0.56 | 0.75 | 59 | 61 |
| EasyToUseBICorr | BIEasyToUseCorr | 4.29E-007 | 32.45 | 0.36 | 0.60 | 58 | 60 |
| BIEasyToUseCorr | EasyToUseBICorr | 4.29E-007 | 32.45 | 0.36 | 0.60 | 58 | 60 |
| EnoughTrainingCorr | WhereToFindHelpCorr | 4.61E-007 | 32.52 | 0.37 | 0.61 | 56 | 58 |
| WhereToFindHelpCorr | EnoughTrainingCorr | 4.61E-007 | 32.52 | 0.37 | 0.61 | 56 | 58 |
| BIEasyToUseCorr | BIToolPerformanceCorr | 5.98E-007 | 31.72 | 0.36 | 0.60 | 56 | 58 |
| BIToolPerformanceCorr | BIEasyToUseCorr | 5.98E-007 | 31.72 | 0.36 | 0.60 | 56 | 58 |
| BIToolPerformanceCorr | JobPerformanceCorr | 2.69E-006 | 27.27 | 0.33 | 0.57 | 56 | 58 |
| JobPerformanceCorr | BIToolPerformanceCorr | 2.69E-006 | 27.27 | 0.33 | 0.57 | 56 | 58 |
| WillingnessToChangeCorr | JobPerformanceCorr | 2.70E-006 | 27.26 | 0.33 | 0.57 | 56 | 58 |
| JobPerformanceCorr | WillingnessToChangeCorr | 2.70E-006 | 27.26 | 0.33 | 0.57 | 56 | 58 |
| EasyToUseBICorr | JobPerformanceCorr | 3.90E-006 | 25.92 | 0.31 | 0.55 | 59 | 61 |
| JobPerformanceCorr | EasyToUseBICorr | 3.90E-006 | 25.92 | 0.31 | 0.55 | 59 | 61 |
| BIEasyToUseCorr | JobPerformanceCorr | 3.92E-006 | 26.00 | 0.31 | 0.56 | 58 | 60 |
| JobPerformanceCorr | BIEasyToUseCorr | 3.92E-006 | 26.00 | 0.31 | 0.56 | 58 | 60 |
| EasyToUseBICorr | IncreaseProductivityCorr | 1.62E-005 | 22.06 | 0.27 | 0.52 | 59 | 61 |
| IncreaseProductivityCorr | EasyToUseBICorr | 1.62E-005 | 22.06 | 0.27 | 0.52 | 59 | 61 |
| IncreaseProductivityCorr | WillingnessToChangeCorr | 4.19E-005 | 19.77 | 0.26 | 0.51 | 56 | 58 |
| WillingnessToChangeCorr | IncreaseProductivityCorr | 4.19E-005 | 19.77 | 0.26 | 0.51 | 56 | 58 |

*Figure 7-30: List of the highest correlated questions (partial). Since every question is compared to every question, doubles occur in the list and can be ignored*

The highest correlation exists between the answers to the questions "I have fun using BI" and "Using BI increases my productivity" It seems having fun has a big impact on the perceived impact on end-user productivity. . It has the highest R-value of all the matches (0.88), but it seems all the answers are pretty skewed and located at the right hand side of the graph.

This could either mean that the model is correct and having a high fun rating means you perceive a high productivity increase, however this could also mean the sample set isn't large enough. Having too few observations could mean the conclusions based on these readings may be flawed, under- or overrated.
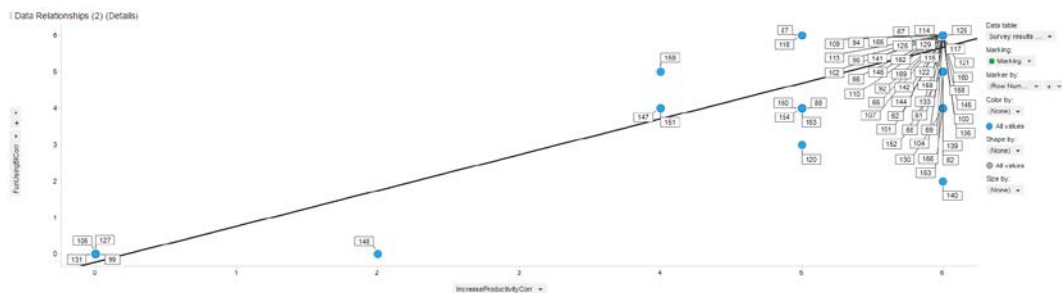


*Figure 7-31: Correlation between productivity and fun using BI questions*

The same situation applies to the next two possible correlations. Both the links between 'perceived increased productivity' and 'perceived job performance' (R-value of 0.84) or 'fun using BI' and 'job performance' have the same type of skewed graph.
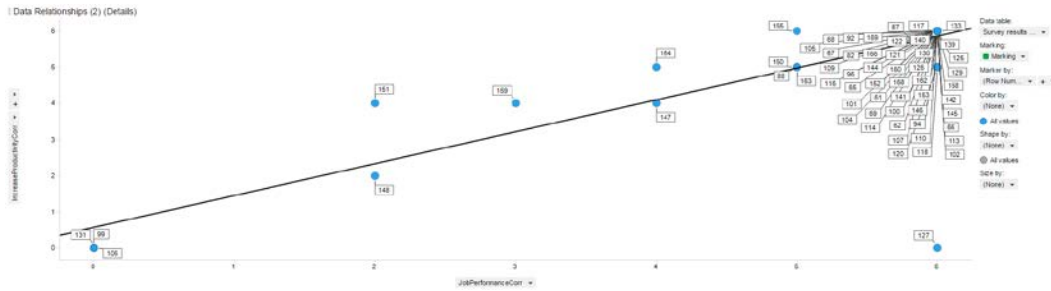
*Figure 7-32: Graph presenting correlation between job performance and perceived increased productivity*
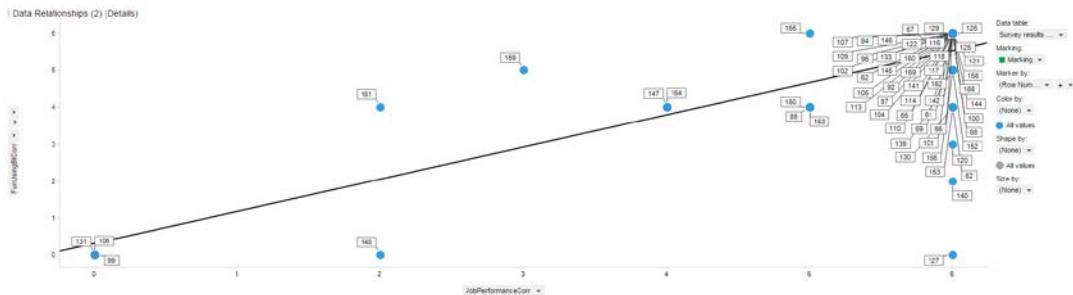


*Figure 7-33: Graph showing correlation between fun using BI and job performance*

A more varied view is shown by the relation between "I know where to find help" and "I received enough training". It seems that people who are accustomed with the proper help channels, or at least indicate they can find help if they need to, agree to some extent they received enough training. This could indicate that people who have access to help resources find their way to the training material or the training material has adequate references to methods of finding help. Since however most people answered they preferred asking a colleague or peer for help, it's possible to assume these colleagues help beginning and occasional BI users to find their way to the proper training resources.
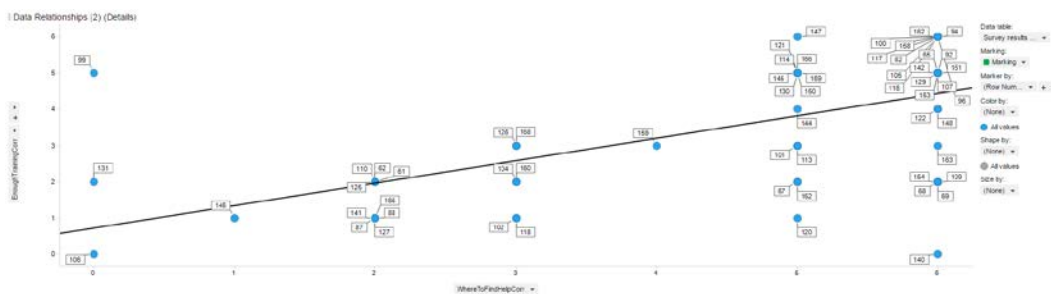


*Figure 7-34: Correlation between having enough training and knowing where to find help*

It also seems that the answers to the question "Does BI increase your job performance" are linked to the question "How do you score the performance of currently used BI tools" (R-value of 0.57). Although people indicate having a high perceived ease of use is a positive influence on job performance, having a high performing BI tool is a big influence as well. It seems though that in this instance

there are some exceptions, where people rate the tool as underperforming or even worse, but still recognize the effect BI has on their job performance. This could be the result of personal inclination the user has towards BI in general or due to the positive BI culture present in the department.
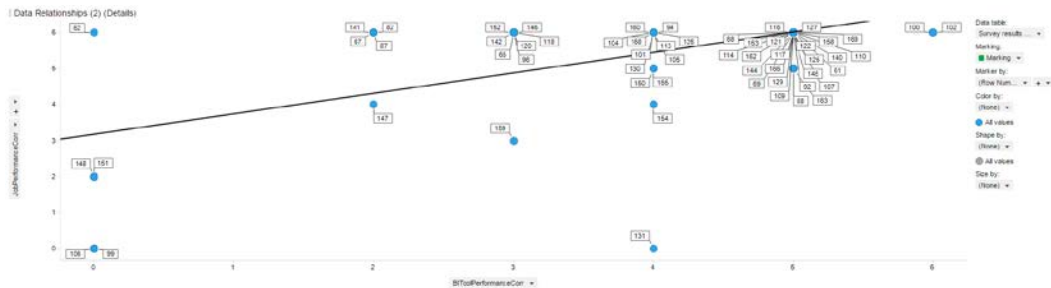


*Figure 7-35: relation between BI tool performance and job performance*

In general it can be noted that several questions have a direct impact on other questions. These include evident matches like for instance if a user has fun using BI compared to if he finds it easy to use BI as less evident matches. It must be noted, as stated before, that a lot of these graphs have a very skewed appearance due to a large clustering at one side. This could result from working with a limited data set, but could also mean people are in accordance with both statements. More testing is required to define a definitive answer to this remark.

For now however, analysis of the data in the dashboards as those gathered from the regression analyses point towards the same issues concerning BI adoption at ASML.

## 1.9 Text analytics

Another way of analyzing the survey data is through text analytics. Text analytics is the process of researching the characteristics of a text in order to make well founded conclusions concerning richness, construction and sentiment of a text. The complete survey results were processed in Python, using Jupyter Notebooks as a workspace. The pandas, numpy and nltk libraries were uses for analyzing the text and visualizing the results. First the entire text was used as a data source. In a second phase of the research all the columns with the Likert scale values were omitted and only the free text input fields were used for further analysis. The complete Jupyter feed is added in the appendices.

The first step of the analyses comprised of loading the survey data as a text file. For ease of access, the Excel workbook was saved as a .txt file in Excel. This text file was then imported both as a pandas data frame and as a raw text string. The next step was to tokenize the raw text file, meaning every single word would become a token in a list of tokens instead of one giant blob string. In the same process, the tokenized list was converted to an nltk.text object and to an nltk.probability object in order to facilitate later use.

```
fdist.most_common(5)

[('agree', 1201),
 ('disagree', 544),
 ('somewhat', 373),
 ('strongly', 337),
 ('neither', 168)]
```

```
fdist.plot(5, cumulative=True)
```
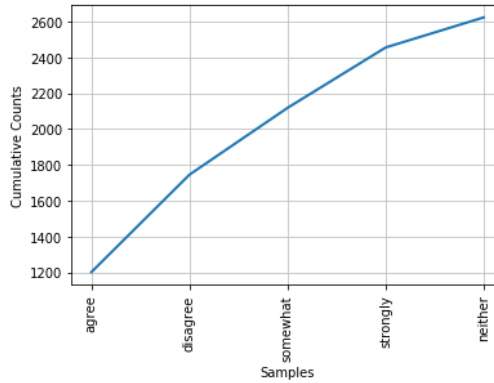


*Figure 7-36: Word count and graphical representation of the top 5 most used words in the survey results*

This probability object could be used to calculate and visualize the most recurring words in the text. Since all the Likert values were included, it's not surprising that 'agree' and 'disagree' are indeed the most present in the text. What is surprising though, is that 'agree' is present more than double the amount of times than 'disagree', meaning in general people are in agreement with the questions of the survey. Number three and four on the list are the adverbs 'somewhat' and 'strongly'. These rankings are also not so surprising, since they are always paired up with 'agree' or 'disagree'. However it does have implications for the level of agreement (or disagreement) of the interviewees with the survey, and mellows down the initial results of the first two keywords.

The same object was also used to visualize the occurrence of words in the general text. As testcases the words 'education', 'training', 'decision', 'performance', 'access' and 'excel' were selected since the Spotfire analysis of the survey data implied these words captured the most of the issues people have with using BI tools.
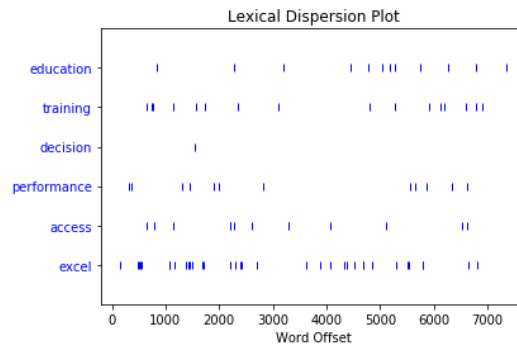
*Figure 7-37: Dispersion plot of the selected keywords in the global survey results text*

The next step in analyzing the results of the survey is making cross column word counts. In using these word counts it's possible to get a bit more insight in the answers in general

| | Measure | Count | Original column |
|---|---|---|---|
| 0 | Education or training present in general | 18 | HelpComments, CurrentImprove and HelpMostComments |
| 1 | Education or training present in most help column | 14 | HelpMostComments |
| 2 | Education or training combined with Excel | 2 | HelpMostComments and BiToolUseComment |
| 3 | Users of Spotfire that need education or training | 8 | Spotfire, HelpMostComments and NumberUsed |
| 4 | Users of Analysis for Office that need education or training | 1 | Analysis, HelpMostComments and NumberUsed |
| 5 | Users that use Spotfire and Analysis for office that need education or training | 0 | Spotfire, Analysis and HelpMostComments |
| 6 | Users that say BI is a good idea, but still use Excel | 22 | All columns |
| 7 | Users that indicate they know how to connect to data but still use access | 5 | All columns |
| 8 | Users that say they need to do calculations with data and use excel | 13 | All columns |
| 9 | Users that say they need to do calculations with data and use access | 3 | All columns |
| 10 | People that do reporting indicating they need more education | 14 | HelpMostComments, CurrentImprove, HelpComments and BIToolUseComments |
| 11 | People doing analyses indicating they need more education | 4 | HelpMostComments, CurrentImprove, HelpComments and BIToolUseComments |
| 12 | People making reports for decisions indicating they need more education | 1 | HelpMostComments, CurrentImprove, HelpComments and BIToolUseComments |

*Figure 7-38: Different cross column word counts*

A general count of the words 'education' and 'training' over various columns teaches that these words are used 18 times. It is most recurring though in the 'Considering BI, what would help you the most' column at the end of the survey.

It's not very surprising, since Spotfire is the most used BI tool that users who use Spotfire indicate they need education or training the most. Only one user that uses Analysis for Offices says he needs more training and the moment users start using two or more tools, the request for more training seems to stop. Probably that more expert users use more than one tool, where report consumers and more occasional report builders use just Spotfire. Since BI reporting isn't the core part of their job (as seen in the boxplot graphs on the BI tool performance dashboard) they have less practice and feel less confident in using BI tools.

As previously stated, almost everyone says BI is a good idea. Even though people are convinced of the benefits of BI, still 22 users indicate they use BI as well as Excel. Five people also indicate they use Access although they agree to the statement they know how to connect to the data source provided by IT. Indirectly

this tells us that there are other reasons why people keep using Access to store data.

When asked if people need to do calculations in order to use the provided data, 13 users say they still use Excel in general, while 5 users say they use Access. If however these tools are used to shape or merge data couldn't be ascertained with any certainty.

Finally an inquiry was made in the way people use BI tools and if they need more training or not. Fourteen people that do reporting also indicate they need more education while only four people that do analyses say the same. Also one person that says he makes decision making reports needs more education as well. This is a possible indication that the main issue with training and education is with the general BI users that do day to day reporting.