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The Analytic Hierarchy Process Used in Evaluation of Projects in Ihmeiden Kehto

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The objective of this thesis was to develop a decision-making tool for a private entrepreneurship Ihmeiden Kehto. The thesis aims to achieve this objective by answering research questions such as how does Analytic Hierarchy Process function as a decision-making methodology and what are its advantages and limitations? What are the priorities of Ihmeiden Kehto when selecting new projects and how can Analytic Hierarchy process be used to consider offers on new projects?

Mixed approach was chosen as a data collection method for this thesis as both qualitative and quantitative data was needed for the thesis. Sequential exploratory research design was used to first conducting a semi structured interview to the entrepreneur of Ihmeiden Kehto. A structured questionnaires were sent to the entrepreneur of Ihmeiden Kehto based on the data that was gained from the interview. Sampling for the interview and questionnaires was chosen based on the objective of the thesis and they were conducted on the entrepreneur of Ihmeiden Kehto. Based on these primary sources the thesis identified four important factors in Ihmeiden decision-making. These four factors were used as decision criteria in the Analytic Hierarchy Process based decision-making tool.

The decision-making tool was developed based on secondary data and the collected primary data. The Analytic Hierarchy Process based decision-making tool uses four important criteria for Ihmeiden Kehto in their project evaluation. The decision-making tool requires the entrepreneur to input judgements for the

compared projects and automates results. The thesis was able to provide Ihmeiden Kehto with a practical Excel-based decision-making tool to enhance their decision making.

Keywords:

Analytical Hierarchy Process, Decision Making, Entrepreneurship

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The Analytic Hierarchy Process Used in Evaluation of Projects in Ihmeiden Kehto

Tämän opinnäytetyön tavoitteena oli kehittää päätöksentekotyökalu toiminimi yritykselle Ihmeiden Kehto. Tavoite pyrittiin saavuttamaan vastaamalla tutkimuskysymyksiin; miten Analyyttinen Hiearkiaprosessi toimii päätöksentekomenetelmänä, sekä mitkä ovat sen hyödyt ja rajoitukset? Mitkä ovat Ihmeiden Kehdon prioriteetit uusien projektien valinnassa, ja kuinka Analyyttistä Hiearkiaprosessia voidaan käyttää uusien projektitarjousten arvioinnissa?

Opinnäytetyön datankeruumenetelmäksi valittiin yhdistelmämenetelmä, koska päätöksentekotyökalun rakentamiseen tarvittiin sekä kvantitatiivista että laadullista dataa. Laadullista dataa kerättiin puolistrukturoidulla haastattelulla, jonka tuloksia tarkennettiin kvalitatiivisilta dataa keräävillä strukturoiduilla kyselyillä. Haastateltavaksi sekä kyselyiden vastaanottajaksi valittiin Ihmeiden Kehdon yrittäjä, koska päätöksenteko perustuu yrittäjän prioriteetteihin. Datankeruun perusteella valittiin neljä kriteeriä Ihmeiden Kehdon päätöksenteossa. Näitä neljää kriteeriä käytettiin Ihmeiden Kehdolle luodussa Analyyttiseen Hiearkiaprosessiin perustuvassa päätöksentekotyökalussa.

Päätöksentekotyökalu kehitettiin opinnäytetyön aikana kerätyn datan sekä kirjallisuuslähteiden perusteella. Analyyttiseen Hiearkiaprosessiin perustuva päätöksentekotyökalu käyttää neljää Ihmeiden Kehdolle tärkeää päätöksentekokriteeriä. Päätöksentekotyökalu vaatii yrittäjää syöttämään kahdenkeskeiset vertaisarvioinnit vertailtaville projekteille, jonka jälkeen

päätöksentekotyökalu automatisoi tulokset. Opinnäytetyö onnistu luomaan Ihmeiden Kehdolle käytännöllisen Excel pohjaisen päätöksentekotyökalun, joka parantaa yrityksen päätöksentekoprosessia.

Asiasanat:

analyyttinen hierarkiaprosessi, päätöksenteko, yrittäjyys

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1 Introduction

Private entrepreneurship is one of the most common company forms in Finland (*Yritysmuodot,* 2023) and is desired form of employment for many instead of the more traditional paid labour. Private entrepreneurship offers many benefits such as freedom of scheduling, simplified accounting, and how relatively easy it is to start this type of business. However, it is not without its unique challenges such as limited access to capital, marketing, and visibility of the business, and decision-making and lack of group of employees to aid in it. (Haapala 2022)

Ihmeiden Kehto is a Finnish private entrepreneurship that offers services ranging from acting courses, movie courses, and computer science courses, to filming and editing of advertisements. The company offers these services to organizations such as local schools, civic collages, and other private companies (www.ihmeidenkehto.fi). The challenge Ihmeiden Kehto faces is that evaluating offers for new projects is often difficult and time consuming.

Evaluation of offers for projects is complicated and the problem is amplified for Ihmeiden Kehto as the entrepreneur needs to make the decisions individually and lack the various advantages group decision-making (Ossadnik et al., 2016). To solve these challenges, various decision-making methods have been developed that can aid decision makers in a group or individually. One such decision-making method is called analytic hierarchy process.

1.1 Research questions and thesis objective

Analytic Hierarchy Process is a multi-criteria decision-making tool that is used to solve decision-making problems with multiple attributes. (Felice et al., 2016). The objective of the thesis is to enhance the decision-making process for evaluating offers on new projects at Ihmeiden Kehto by employing the Analytic Hierarchy Process, culminating in the development and implementation of a practical Excel-based evaluation tool. The following research questions were formed to deliver on this objective:

- What are Ihmeiden Kehto's priorities when selecting new projects?
- How does the Analytic Hierarchy Process function as a decision-making methodology?
- What are advantages and limitations of Analytic Hierarchy Process?
- In what way can the analytic hierarchy process be used to consider offers on new projects in Ihmeiden Kehto?

The thesis will attain theoretical understanding on Analytic Hierarchy Process by reviewing scholarly sources. Additionally, the entrepreneur of Ihmeiden Kehto is interviewed to gain understanding on what factors are present and important in their decision-making. The thesis aims to present the optimal way to use Analytic Hierarchy Process for Ihmeiden Kehto based on this information.

1.2 Ihmeiden Kehto

Ihmeiden Kehto is a small Finnish one-man business located in Mikkeli that offers services such as acting courses, movie courses, computer science courses, filming and editing of advertisements and other related projects. Organisations who buy these services include, but are not limited to, civic collages in Mikkeli and neighbouring towns, local middle and high schools and various other independent organizations. For Ihmeiden Kehto to be able to offer these services they need to plan and organize the project or course, create materials for the course, and travel to the location where these services will be provided. Planning, organizing, and creation of materials take considerable amount of time and for

this reason are factors considered when calculating offers for new projects or courses (Appendix 1).

For a business like Ihmeiden Kehto, that offers services that are performed by the sole person who owns the business, time is important resource. The business receives offers and offer requests for new projects frequently and evaluating of these offers independently relying solely on expertise of the entrepreneur takes considerable amount of time. In addition to planning time mentioned earlier, several factors are considered when calculating offers for new projects or courses. Revenue for the project is calculated as the total amount of pay generated for the whole project or course period but is compared to other projects or courses using hourly pay as a comparison. Hourly pay is calculated by dividing the total revenue with the sum of active service hours, planning hours, and possible editing hours. This method is being used to make comparisons of large yearlong projects and shorter month-long projects possible (Appendix 1). Ihmeiden Kehto considers factors such as travel distance and personal enjoyment whenever possible but mentions in an interview (Appendix 1) that evaluation of these factors is difficult. They also mention that these factors should be considered more in their decision-making process, and they wish that the process would be more efficient.

2 Analytic Hierarchy Process as a decision-making method

Before Analytic hierarchy process can be explained, we first need to understand what a decision-making method is and why Analytic Hierarchy Process was chosen to be used for this thesis work. The chapter will next explain in detail what a decision-making method is and what different kinds of decision-making methods are being used. Then the chapter will explain what the Analytic Hierarchy Process is and what is its purpose in decision-making. Before giving a deeper explanation on how the Analytic Hierarchy Process works, the thesis will discuss how Analytic Hierarchy Process was developed and by whom, and how it has been iterated since. Then, a detailed explanation is given on how the Analytic Hierarchy Process is used and done. The last part of the chapter will explain the business model of the case company Ihmeiden Kehto and discuss what specific criteria is important for the company and what type of criteria is important for similar type of businesses in general in relation to the Analytic Hierarchy Process.

2.1 Decision-making methods

One way to define decision-making method is to describe it as selecting an option from a list of possibilities. Decision-making is present in our daily lives from simple decisions such as where we choose to eat, to longer period decisions we make such as which house to buy. Decisions can also be made in even longer period such as government policy decisions (Márquez, 2019). There are many different decision-making methods, and for this chapter they have been divided into three different categories: simple decisions-making methods, group decision-making methods, and structured multi-criteria decision-making methods. Next his chapter will provide examples of different decision-making methods and explain why analytic hierarchy process was chosen to be used for this thesis work.

Simple decisions can be made using various methods, one of which is called satisficing method. In this method, decision-maker decides based on minimal satisfactory values. The method does not necessary result in optimal decision, but any decision done would be satisfactory (Mcsweeney, 2010). Example of this method would be if the entrepreneur at Ihmeiden Kehto would be deciding if they should accept a project and decides that a minimal satisfactory amount of payment for the project would be 10000€. If the entrepreneur receives an offer that exceeds the minimal satisfactory amount, they decide to accept the project and if the offer is below the minimal satisfactory value, they would decline the offer. Limitation of this method is that it does not take in account if an offer is more satisfactory than the other and simply chooses the option that is satisfying (Mcsweeney, 2010).

Another example of simple decision-making methods is intuitive decision-making. In this method the decision-maker decides between option based on intuition. This is an effective and often used method when a person is making a simple decision, for example deciding what type of coffee to buy. One option feels like the correct one for the decision-maker and they choose that one (Betsch, 2004). This method is effective way to make everyday decisions that does not have great importance or have low possibilities for regret. Neither of these simple decision-making methods are comprehensive enough for the needs of Ihmeiden Kehto in their decision making, and it is reasonable to suppose that other simple decision-making methods are similarly lacing for this purpose.

Group decision-making is another group of decision-making methods. These methods utilize benefits that come with group-based decision-making such as, additional perspectives and professional expertise of multiple decision-makers. These methods can additionally reduce the effect of individual biases in the decision-making (Bang & Frith, 2017). Ihmeiden Kehto is a private entrepreneur and does not have a steady access to a group of people in the business to use in these methods. What these methods have in common is that they rely on the group to make the decisions and as such these methods do not fulfil the needs

of this thesis. The chapter will next focus on methods that can be done by an individual and are comprehensive enough for the needs of Ihmeiden Kehto.

Decision-making method needed for Ihmeiden Kehto to evaluate project offerings is one that can assess multiple criteria and assign weights for these criteria. Weighted Sum Model is one such method and it can be used to evaluate and rank alternatives using multiple criteria. In this method, the decision-maker chooses criteria to be used in a decision and assigns weight for each criterion based on its importance in the decision. Then, a weighted score is calculated for alternatives in the decision based on the weighted criteria. The decision in the method is made by ranking the alternatives based on the alternatives weighted score (Danielson & Ekenberg, 2023). Weighted sum model is used in evaluation of project proposals because it enables decision-makers to customise the model based on objectives of the decision. The Weighted sum model is close to what is needed in decision making in Ihmeiden Kehto, but the model lacks the capability to compare both qualitative, and quantitative data (Triantaphyllou & Sánchez, 1997). Comparison using both types of data are necessary as described later in the chapter 2.4.1 Important criteria for Ihmeiden Kehto. This is why Analytic Hierarchy Process that uses relative values rather than absolute values, or absolute measurements, was selected as a decision-making method for the thesis work (Ossadnik et al., 2016).

2.2 Analytic hierarchy process

Analytic hierarchy process is a decision-making method that can be described as a structured technique that is based on mathematics and psychology and is used to analyse complex decisions (Mu & Pereyra-Rojas, 2018). Whereas previously described decision-making methods can be useful in simpler decision made as a private entrepreneur, a problem arises when decision-making includes intangible criteria, criteria that cannot be defined in the same scale than another criterion. When deciding between two alternatives, for example deciding between two cars to buy, price of the car and safety features of the car may be important criteria for purchaser. Problem is that these criteria are evaluated in a different scale, like

euros and perception of increased safety. The decision-maker cannot make an accurate mathematical decision on the purchase when using for example, the Weighted Sum Model and would rather need to use a method that derives relative scales for both criteria and alternatives. The scales would need to have weighting and adding process for the criteria that would make the scales comparable (Saaty, 2004). Analytic Hierarchy Process is this type of decision-making method.

Analytic Hierarchy Process allows decision maker to use intangible and tangible criteria in decision making (Ossadnik et al., 2016), for example a private entrepreneur can use the method to compare how much they find enjoyment in a potential project with the amount of revenue the project will generate, and to the travel distance to the location of the project. This is achieved by making pairwise comparisons with each criterion used in a decision to define a weighting for each of the criteria. What this means in practise is that decision-maker will compare the different criteria in pairs and decide which is more important. For example, Ihmeiden Kehto could deem that higher pay is more important than traveling distance to the location of a project. This allows decision maker to calculate a weighted score for the different criterion and calculate a weighted score for each alternative projects based on these weighted criteria. This allows the decision-maker to compare the project to other potential projects to decide which one is closest to company goals and objectives.

Analytic Hierarchy Process is a useful tool for decision-maker, but most of the time it cannot automatically make the decision for the decision-maker. It can only give ranking of variables, or project offerings in the context of the thesis, and it cannot calculate factors that were not considered, present or important at the point when the Analytic Hierarchy Process was done (Mu & Pereyra-Rojas, 2018). Professional expertise is usually needed to make the decisions in professional settings that may not be possible to be taken in consideration in the Analytic Hierarchy Process. For example, Ihmeiden Kehto could get a better than average offer based on the Analytic Hierarchy Process weighted scores. Based on their professional expertise, the decision-maker would know that it would be impossible to fit the project into the company schedule. In this instance, the

decision-maker would likely need to decline the offer even if the score in the Analytic Hierarchy Process would be higher than some other already agreed upon projects. This means that Analytic Hierarchy Process is a powerful tool that can be used in assistance of decision-making alongside with the professional expertise of the decision-maker, which in the case of this thesis is the private entrepreneur who operates Ihmeiden Kehto.

Before providing detailed explanation on how the Analytic Hierarchy Process works with an example and mathematical foundations is provided later in the chapter, the thesis will next discuss the history of Analytic Hierarchy Process and how the decision-making method have been developed.

2.2.1 History of Analytic Hierarchy Process

The Analytic Hierarchy Process is a multicriteria decision-making tool developed by Thomas L. Saaty while he was a university professor at Pittsburgh university in 1971-1975 (Saaty, 1990). According to Saaty (1988) Analytic Hierarchy Process is a process that considers factors that influence a decision, such as perceptions, judgements and feelings and is based on ability of the decision-maker to make judgements on small problems. The process does this by deriving ratio scales using pairwise comparisons that can be both actual measurements and measurements from a fundamental scale (Saaty, 1987). These measurements used in the ratio scales can be for example price of an item that is an actual measurement and how nice the item looks that is a measurement that is from a fundamental scale. Saaty (1988) argues that by using Analytic Hierarchy Process, the decision-maker uses judgements that are based on factors such as intuition, emotion, and logic.

Scholars and researchers have made important contributions to further development of the Analytic Hierarchy Process (Ishizaka & Labib, 2011). One of the important contributors is Luis G. Vargas who is a senior editor in the international journal of the analytic hierarchy process and focus of his research is decision theory and practical applications of Analytic Hierarchy Process. He

has collaborated with Saaty on many publications focused on the Analytic Hierarchy Process and has contributed to application of the Analytic Hierarchy Process in areas such as decision-making and resource allocation (University of Bittsburgh,2022). Another important contributor in the development of the Analytic Hierarchy Process is Ernest H. Forman who has published several articles and books discussing Analytic Hierarchy Process, focussing on methodologies and applications. Additionally, he has developed one of the first computer software implementations of Analytic Hierarchy Process that is now widely used by governments and businesses globally (GW School of Business, 2024).

2.2.2 How to use Analytic Hierarchy Process

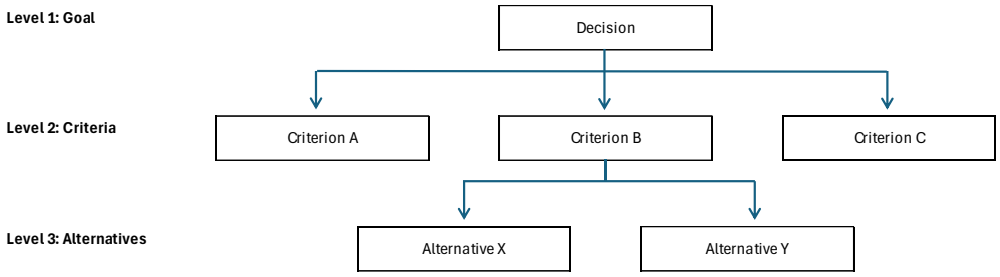
In this chapter the thesis will provide a detailed description on how Analytic Hierarchy Process works and explains what is done in each of the steps of Analytic Hierarchy Process analysis. The thesis will do this by using an example decision analysis between alternative X and alternative Y. The following steps are done to reach a decision: decision hierarchy, priorities of the criteria, consistency ratio, priorities of the alternatives, overall priorities, sensitivity analysis, and final decision (Mu & Pereyra-Rojas, 2018).

2.2.2.1 Decision hierarchy

The starting point of Analytic Hierarchy Process analysis is to define a hierarchy for the decision. For the example decision, the goal is to decide between two alternatives using three criteria (Mu & Pereyra-Rojas, 2018). As shown in table 2-1**,** hierarchy for this decision can be divided into three levels: goal of the decision or what is being decided on, criteria that are considered in the process, and alternatives or options for the result of the decision. The described hierarchy is called a three-level hierarchy as it consists of three different levels. If the decision was a more complex one, fourth level of sub criteria could be added to the hierarchy (Saaty & Vargas, 2012). Use of these sub criteria is not necessary in the decision process done in the example and was not needed in the Analytic

Hierarchy Process tool provided in this thesis, and for this reason they will not be used in the example.

Table 2–1: Decision hierarchy (Heinonen, 2024)



2.2.2.2 Priorities of the criteria

Second step of the analysis is to define weights for the different criteria used in the process. This is called deriving relative priorities for the criteria and these relative priorities, or wights, are obtained by doing pairwise comparisons between the criteria. The pairwise comparisons for the criteria are done by using a numerical comparison scale developed by Saaty (2004) that is shown in table 2-2. The comparison scale provides verbal judgements with set numeric values that are used to compare criteria in pairs. The pairwise comparisons are done to create a pairwise comparison matrix (table 2-3) to gain the relative preferences of each compared criterion pair (Mu & Pereyra-Rojas, 2018). This means that if as in the example, criterion A is moderately more important than criterion B, it would be assigned a value of 3. Respectively, criterion B then has importance of 1/3 when compared to criterion A. Finally, when a criterion is compared against itself, it is always equally important. These comparisons are done until the comparison matrix is complete.

Table 2-2: Comparison scale (Saaty, 2004)

Judgement	Value
Extremely important	9
	8
Very strongly important	7
	6
Strongly more important	5
	4
Moderately more important	3
	2
Equally important	1

Table 2-3: Pairwise comparison matrix (Heinonen, 2024)

Decision	Criterion A	Criterion B	Criterion C
Criterion A	1	3	4
Criterion B	1/3	1	2
Criterion C	1/4	1/2	1

Next part of weighting the criteria is to do a column addition. This is done by converting the pairwise comparison matrix to a one with numeric values and calculating a sum for each criterion with its comparison values with other criterion (Mu & Pereyra-Rojas, 2018). In table 2-4 it is shown that for the example this would mean that the sum of criteria A would be calculated by adding its comparison value of itself of 1,000, comparison value with criterion B of 0,333, and comparison value of criterion C of 0,250. This gives the criterion A, a sum of 1,583. This column addition table is used to calculate a normalized matrix. Normalization of this matrix is done because this process uses what is called approximate method, one of two methods that can be used to calculate the pairwise comparisons (Mu & Pereyra-Rojas, 2018). This is done by dividing each of the pairwise comparisons with the sum of each column. The result of this calculation in the example is shown in table 2-5.

Table 2-4: Column addition (Heinonen, 2024)

Decision	Criterion A	Criterion B	Criterion C
Criterion A	1,000	3,000	4,000
Criterion B	0,333	1,000	2,000
Criterion C	0,250	0,500	1,000
Sum	1,583	4,500	7,000

Table 2-5: Normalized matrix (Heinonen, 2024)

Decision	Criterion A	Criterion B	Criterion C
Criterion A	0,632	0,667	0,571
Criterion B	0,210	0,222	0,286
Criterion C	0,158	0,111	0,143

After the comparison matrix is normalized, final priorities for each criterion are calculated by calculating average for each row in the table. (table 2-6) This final priority is the weight of the criterion. A common way to show results of this step, is to show a table with the original judgements as shown in the column addition table (table 2-4) and final priority values for the criteria (Mu & Pereyra-Rojas, 2018). The presentation of results is shown in table 2-7.

Table 2-6: Calculation of priorities: row averages (Heinonen, 2024)

Decision	Criterion A	Criterion B	Criterion C	Priority
Criterion A	0,632	0,667	0,571	0,623
Criterion B	0,210	0,222	0,286	0,239
Criterion C	0,158	0,111	0,143	0,137

Table 2-7: Presentation of results (Heinonen, 2024)

Decision	Criterion A	Criterion B	Criterion C	Priority
Criterion A	1,000	3,000	4,000	0,623
Criterion B	0,333	1,000	2,000	0,239
Criterion C	0,250	0,500	1,000	0,137

As the process uses the approximate method, consistency of the model needs to be checked when there are more than two variables in the comparison matrix. Consistency, or consistency ratio (CR) of the model is calculated by comparing consistency index (CI) of the comparison matrix to a random-like matrix (RI) (Mu & Pereyra-Rojas, 2018). Consistency index is calculated by first multiplying original judgements with the final priority values as shown in table 2-8. This results in what is called weighted columns, and it is shown in table 2-9. A weighted sum is calculated using the weighted columns table by calculating a sum of each row (Mu & Pereyra-Rojas, 2018) as shown in table 2-10.

Table 2-8: Priorities as factors (Heinonen, 2024)

Decision	Criterion A	Criterion B	Criterion C
Criteria weights	0,623	0,239	0,137
Criterion A	1,000	3,000	4,000
Criterion B	0,333	1,000	2,000
Criterion C	0,250	0,500	1,000

Table 2-9: Calculation of weighted columns (Heinonen, 2024)

Decision	Criterion A	Criterion B	Criterion C
Criterion A	0,623	0,718	0,549
Criterion B	0,208	0,239	0,275
Criterion C	0,156	0,120	0,137

Table 2-10: Calculation of weighted sum (Heinonen, 2024)

Decision	Criterion A	Criterion B	Criterion C	Weighted sum
Criterion A	0,623	0,718	0,549	1,891
Criterion B	0,208	0,239	0,275	0,722
Criterion C	0,156	0,120	0,137	0,413

Finally, before calculating the consistency index, a value of $Lambda_{max}$ needs to be calculated by first dividing the weighted sum from previous table by the final priority values. This calculation is repeated for each of the criterion. These values are then added together and divided by the number of criteria to gain $Lambda_{max}$ value as shown in table 2-11. At this point, the consistency index can be calculated. This is done by first subtracting the number equal to the number of criteria from $Lambda_{max}$ value. Then subtracting one (1) from number equal to the number of criteria. Finally, these calculations are divided by each other to gain the consistency index (Mu & Pereyra-Rojas, 2018). In the example this calculation would be (3,018 – 3) / (3 - 1) = 0,009. Consistency index in the example is shown in the table 2-11. Now that the consistency index is calculated, only random-like matrix value is needed. The random matrix is the value of 500 consistency indexes of randomly filled comparison matrices. The random matrix used in this thesis was published by Mu & Pereyra-Rojas (2018) and is shown in table 2-12.

Table 2-11: Calculation of $Lambda_{max}$ (Heinonen, 2024)

Weighted sum	priority	
1,891	0,623	3,034
0,722	0,239	3,014
0,413	0,137	3,007
	Total	9,054
	Divide by 3	3,018
Consistency index		0,009

Table 2-12. Random-like matrix (Mu & Pereyra-Rojas, 2018)

n	3	4	5	6
RI	0,58	0,90	1,12	1,24

Then all that is left is to calculate the consistency ratio using the consistency index and the random-like matrix. Calculation of this ratio is defined as CR = CI/RI and in the example, this would be calculated as 0,009/0,58 = 0,016. When the value of consistency ratio is below 0,1 the model is considered consistent (Mu & Pereyra-Rojas, 2018). If, however, the consistency ratio is higher than 0,1 it would indicate that there are inconsistencies in the original judgements of the criteria, and that they would need to be adjusted before the weighted criteria should be used in the next step of the process.

2.2.2.3 Priorities of the alternatives

Next step of the process is to calculate local priorities for the alternatives. This is done by comparing each of the variables against each other in context of each criterion separately. In the example this means that at first alternative X is compared to alternative Y specifically in respect of criterion A. This is done by making similar comparison matrix using the 1-9 judgements as earlier when calculating weighted criteria, but this time with the alternatives. When the judgements are assigned for the alternatives, a sum is calculated for each alternative. In the example when the alternatives were compared against each other in respect of criterion A. Alternative X were considered moderately more important than alternative Y. This gave alternative X a judgement of 1,000 against itself and judgement of 3,000 against alternative Y. Respectively Alternative Y gained a judgement of 0,333 against alternative X and judgement of 1,000 against itself. Then a sum is calculated for each alternative as shown in table 2-13. Priority of the alternatives in respect to criterion A were calculated by dividing each judgement with the sum of each alternative. After these calculations were done, an average was calculated for each alternative to gain a priority value (Mu & Pereyra-Rojas, 2018). In the example, priority of Alternative X is 0,750 and

alternative Y is 0,250 when compared in respect to criterion A. Results of this calculations with the priority values and original judgments are shown in table 2-14.

Table 2-13: Comparison with criterion A (Heinonen, 2024)

Criterion A	Alternative X	Alternative Y
Alternative X	1,000	3,000
Alternative Y	0,333	1,000
Sum	1,333	4,000

Table 2-14: Result with criterion A (Heinonen, 2024)

Criterion A	Alternative X	Alternative Y	Priority
Alternative X	1,000	3,000	0,750
Alternative Y	0,333	1,000	0,250

This calculation is repeated for each of the criterion used in the process. Priority values for alternatives when compared to the remaining two criteria, were calculated by using the same method as in the previous example. This was done by assigning judgements for the alternatives when they are compared against a single criterion. Then, a sum of these judgement is calculated for each column. Finally, the judgements are divided with the sum of the column for each alternative. If there were three or more alternatives that were compared, a consistency of these judgements would be checked in the same way as was done with the criteria. A summary of results for each criterion with original judgements and the priority value is shown in table 2-15.

Table 2-15: Summary of local priorities (Heinonen, 2024)

Criterion A	Alternative X	Alternative Y	Priority
Alternative X	1,000	3,000	0,750
Alternative Y	0,333	1,000	0,250
Sum	1,333	4,000	

Criterion B	Alternative X	Alternative Y	Priority
Alternative X	1,000	0,250	0,200
Alternative Y	4,000	1,000	0,800
Sum	5,000	1,250	

Criterion C	Alternative X	Alternative Y	Priority
Alternative X	1,000	0,166	0,143
Alternative Y	6,000	1,000	0,857
	7,000	1,166	

2.2.2.4 Model synthesis

Now that the priority of criteria and priority of alternatives in respect to the criteria are calculated, the next step of the process can be done, called model synthesis. This is done to calculate overall priority for each alternative in the process, which results in a ranking that can be used in the decision making. The model synthesis is calculated by using the local priorities of each alternative in respect to each criterion and the priority values of the criteria (Mu & Pereyra-Rojas, 2018). These values were calculated for the example in the previous steps and are shown in table 2-16.

Table 2-16: Weighting of priorities (Heinonen, 2024)

	Criterion A	Criterion B	Criterion C
Criteria Weights	0,623	0,239	0,137
Alternative X	0,750	0,200	0,143
Alternative Y	0,250	0,800	0,857

Next an overall priority is calculated for each alternative. This is done by multiplying the local priorities with their respective criteria weights. In the example

this means the local priority of alternative X in respect to Criterion A is multiplied with the priority of criterion A. This means that weighting priority of alternative X with criterion A is 0,750 * 0,623 = 0,468. This calculation is repeated for each local priority. Last step of the model synthesis is to calculate sum of the weighted priorities for each alternative to gain the overall priority (Mu & Pereyra-Rojas, 2018). In the example this means that alternative X overall priority is 0,468 + 0,048 + 0,020 = 0,535. Result of these calculations in the example is shown in table 2-17. Additionally, a result with criteria priorities, local priorities and overall priority is presented in table 2-18.

Table 2-17: Overall priorities (Heinonen, 2024)

	Criterion A	Criterion B	Criterion C	Overall priority
Criteria Weights	0,623	0,239	0,137	
Alternative X	0,468	0,048	0,020	0,535
Alternative Y	0,156	0,192	0,118	0,465

Table 2-18: Model synthesis (Heinonen, 2024)

	Criterion A	Criterion B	Criterion C	Overall priority
Criteria Weights	0,623	0,239	0,137	
Alternative X	0,750	0,200	0,143	0,535
Alternative Y	0,250	0,800	0,857	0,465

This overall priority value is the result of Analytic Hierarchy Process and form the values we can see that alternative X performs slightly better than alternative Y. Alternative X has overall priority of 0,535 and alternative Y has overall priority of 0,465. This means that the difference between these alternatives is not large, but it indicates that the decision maker should consider alternative X more attractive option. However, before a final decision is made, some additional analysis should

be conducted on the results. This analysis in the process is called sensitivity analysis.

2.2.2.5 Sensitivity analysis

The goal of sensitivity analysis is to understand why a certain decision is made and what forces contribute the most on the decision in the process. Mu & Pereyra-Rojas (2018) explain two commonly used scenarios that are used to do the sensitivity analysis. First scenario that is used to analyse the process is to change the criteria weights, or priorities of criteria to be equal in the model synthesis. In the example, this gives alternative X an overall priority of 0,364 and alternative Y an overall priority of 0,635. In this scenario alternative Y is far more attractive option to a decision maker and indicates that the criteria weighting has a strong influence in the model. This scenario with the example model synthesis is shown in table 2-19.

Table 2-19: Scenario: all criteria have the same weight (Heinonen, 2024)

	Criterion A	Criterion B	Criterion C	Overall priority
Criteria Weights	0,333	0,333	0,333	
Alternative X	0,750	0,200	0,143	0,364
Alternative Y	0,250	0,800	0,857	0,635

The purpose of the second scenario is to analyse how much the most influential decision criteria influences the decision. This is done by first identifying the highest criteria weight. In this example, the criterion A had the highest criteria weight of 0,623. Next all the other criteria weights are equalised, and the most influential criteria is increased or decreased to a point where overall priority is equal. In the example, equal state in the overall priorities were achieved when the most influential criterion A were set 0,568 and criterion B and criterion C were equalised to 0,216. Analysis of the second scenario indicates that if the importance of criterion A in the decision-making process is over 56% Alternative

X becomes the more attractive option. The second sensitivity analysis scenario in the example process is shown in table 2-20.

Table 2-20: Scenario: equal overall priority (Heinonen, 2024)

	Criterion A	Criterion B	Criterion C	Overall priority
Criteria Weights	0,568	0,216	0,216	
Alternative X	0,750	0,200	0,143	0,500
Alternative Y	0,250	0,800	0,857	0,500

2.2.2.6 Final decision

Now that the Analytic hierarchy process is completed and a sensitivity analysis is done, a final decision can be made. The process gave alternative X a slightly better score of 0,535 when compared to alternative Y with a score of 0,465. This means that according to the process the decision-maker should consider alternative X as a slightly better option. However, the decision-maker should be aware that the model is strongly influenced with the criteria weights and without those weights alternative Y would have been much more attractive option. Another point of consideration is that the criterion A influenced the model by 56.8%. This means that the decision-maker should consider if the importance of criterion A to the decision is less than 56.8% then alternative Y becomes the more attractive option. Respectively if the importance of criterion A is more than 56.8% to the decision it would mean that alternative X is more attractive (Mu & Pereyra-Rojas, 2018).

2.3 Important criteria for Ihmeiden Kehto

The important criteria to be used in the analytic hierarchy process-based Excel tool for Ihmeiden Kehto were chosen based on information collected in an interview of the entrepreneur. In the interview four important criteria were

identified as being most important factors for Ihmeiden Kehto when considering offerings for new projects or courses. These criteria were revenue, traveling distance, future potential, and personal enjoyment. Next the chapter will specify why each of the four criteria were chosen.

Small businesses often focus on generating more sales to increase business or fix a bad situation, but often the reason for the problem is in the costs or bad margins (Reider, 2008). For a traditional small business this could mean excessive costs on some materials or too high personnel costs. Ihmeiden Kehto provides a service which can be, for example an acting course for agreed amount of payment. This payment is often calculated by the amount of teaching hours included in the service, but it excludes hours used for planning and travelling. Even though, Ihmeiden Kehto does not have as much recurring costs as a traditional small business would, the hours used for travelling and planning would be considered as costs. This is because those hours do not generate any revenue for the business and as the service product of the company is the owners time (teaching, directing, or editing) it should be taken in consideration when considering offers for new projects.

It was decided that the best way to take these factors in consideration in the criteria was to include planning hours for projects as part of total hours used when calculating the hourly rate of the project (Appendix 1). Using hourly rates is a calculating method most used by most organizations working with Ihmeiden Kehto when asking for project offers (Appendix 3). Ihmeiden Kehto calculates total revenue of a project by overall pay generated by the project (Appendix 2), but it makes comparisons difficult between projects of different lengths (a week, a month, a year). This led to a decision of using combined hourly rate of both active hours used and planning hours used as one criterion for the Analytic Hierarchy Process. Hours used in travelling however have not been counted as part of the hourly rate, and it was more convenient for Ihmeiden Kehto to consider this cost as a separate factor (Appendix 1). Additionally travelling distance has a different level of importance (Appendix 2) to Ihmeiden Kehto than revenue which would result in difficulties when weighting the different criteria. For these reasons

hourly rate and traveling distance were separated as two separate criteria for the Analytic Hierarchy Process.

Potential for future business is an important criterion for Ihmeiden Kehto when considering offerings for now projects. In case of Ihmeiden Kehto this means how likely it is for the organization to be interested in additional projects, or if the project has potential for important networking (Appendix 1). Good future potentials would include factors such as a project for an organization that has previously not been purchasing services from the company, such as civic collage in a neighbouring town. It could also include projects for organizations with potential for networking such as large private organizations or businesses. Additionally potential for future business could be a project for an organization that Ihmeiden Kehto wants to work more closely in the future, such as local schools. Potential for future business was chosen as one of the criteria for analytic hierarchy process because it is an important factor for Ihmeiden Kehto when considering offerings for new projects or courses (Appendix 1).

Personal enjoyment is another important criterion for Ihmeiden Kehto when evaluating offerings for new products. In an interview held with the entrepreneur personal enjoyment was a factor that they wanted to be included in their decision-making process (Appendix 1). It is a factor in the decision-making process that has so far been a difficult one to evaluate for the company because accurately comparing it with other factors such as revenue is difficult. The entrepreneur uses a large portion of a workday working on various projects and as such finding enjoyment from this work is important. Personal enjoyment was chosen as a criterion for analytic hierarchy process because it is important for the entrepreneur, and largely influenced the choice of decision-making method for the thesis. As stated earlier, intangible factors such as personal enjoyment are difficult to compare with tangible factors such as revenue, and as analytic hierarchy process can do this, it was chosen as the decision-making method.

3 Methodology Data collection methods

The thesis was completed as a research-based thesis and mixed-methods approach was chosen as a research methodology. The method was chosen for this thesis because collection of both qualitative and quantitative data was required to achieve the thesis objective. In mixed-method research, data collection is done with both, quantitative and qualitative methods and are combined in various ways (Saunders et al., 2019). The way mixed-method approach was used in the thesis was sequential exploratory method where quantitative data was first collected in a form of an interview, and questionnaires were created using the data gathered from the interview. Additionally, a set of business data was reviewed to gain deeper understanding on what factors Ihmeiden Kehto monitors for their decision-making.

Theoretical data for the thesis was collected by reviewing relevant scholarly sources such as books and journal articles. Reviewing these sources provided theoretical context on what Analytical Hierarchy Process is and how it is done. Additional scholarly sources were reviewed to gain understanding on what decision-making methods are and what type of methods are being used. Works discussing small business practices and businesses in culture were also reviewed to give context to what factors are important for Ihmeiden Kehto when considering offerings for new projects and courses. Although, the final decision on what important criteria were chosen to be used in the Excel-based decision-making tool were based on the preferences and needs of Ihmeiden Kehto. The reason for this decision is that the decision-making tool is specifically being developed for the use of Ihmeiden Kehto.

Empirical data for the thesis was collected as qualitative and quantitative data using an interview and questionnaires. Interview was used to gain understanding on how Ihmeiden Kehto operates as a business and what factors are important when deciding between offerings for new projects. Questionnaires were used to define importance of the criteria and when doing pairwise comparisons on the chosen criteria. Additionally, business data was collected to gain understanding

on important factors for the company. The chapter will next describe in detail how this data was collected and used.

3.1 Business data

A set of business data were acquired from Ihmeiden Kehto which included a set of projects done for various organizations, locations, and time periods. The data included revenue generated and planning required for each project, organization, or business the project or course was done for, in which location it was done and over which period it was completed. This data was analysed and used to gain better understanding on how Ihmeiden Kehto monitors past projects and courses and uses this information when evaluation potential new offers. This set of data is included in Appendix 3. Information that was not used in the thesis were excluded from the appendix such as specific descriptions of organizations, and weekly and yearly number of hours used on each project.

3.2 Interview

An Interview was conducted to gather understanding about Ihmeiden Kehto and how the business operates. The entrepreneur was asked to describe what kind of services they offer and to what type of organizations and customers. The entrepreneur was also asked to describe how offers for now projects were calculated and what were important factors for the business when doing this. Some specifying questions were asked relating to the important factor that were considered in the project offering to gain deeper understanding on why they were important.

From the interview it was derived that Ihmeiden Kehto offer various services to schools, community colleges, and other independent organizations in Mikkeli and it’s surrounding areas. Services that Ihmeiden Kehto offer vary from movie and theatre related courses, editing and computer science courses to web courses. The interview identified that revenue is important criteria for Ihmeiden Kehto when

choosing projects. Ihmeiden Kehto calculates revenue for a project using total amount of revenue generated but uses hourly rate when comparing projects. According to the entrepreneur this is done to make the comparison of short-term and long-term projects easier. Another identified criterion was future potential, which includes likelihood for a project to result in additional projects and networking potential. The entrepreneur also stated that travel distance to a location of a project has some weight in the decision. In the interview, the entrepreneur also reveals that they would like to prioritize projects based on how interesting the project is or how much they would like to do it. The four important criteria used in decisions at Ihmeiden Kehto were chosen based on this interview and are used in the Excel-based decision-making tool. The use of these four important criteria is expanded upon in the next chapter.

The Interview was conducted as a semi-structured online interview where the entrepreneur of Ihmeiden Kehto was interviewed in real time. Semi-structured interview format was chosen to gain data on specific topics about the company Ihmeiden Kehto and because the format allowed more flexibility (Saunders et al., 2019). The main questions of the interview were chosen based secondary data that was reviewed for the thesis. Some of the questions in the interview were based on answers gained in the interview and it was the reason why flexibility was needed in the interview. This interview was recorded, and a transcript of this interview is included in Appendix 1. Ihmeiden Kehto as a company consists of a single person, the entrepreneur, and for this reason only one person was used as an interview sample to gather data for the thesis. Use of only one interviewee is justified as the aim of the thesis is to develop an Excel-based decision-making tool that is tailored specifically for the entrepreneur. However, inclusion of only a single interviewee exposes the collected data to the bias of the interviewee when discussing important criteria in their decisions. Specifically, this means that the important criteria that were identified for Ihmeiden Kehto may not apply for other users of Analytic Hierarchy Process. If a similar process would be developed using this thesis as a basis, important criteria would need to be identified specifically for the decision-maker using the process.

3.3 Questionnaire

After the criteria to be used were chosen based on the information gathered in the interview, a questionnaire was sent out to the entrepreneur. A purpose of the structured questionnaire was to evaluate the importance of each of the criteria identified in the interview. Sampling for the questionnaire was the same as for the interview, and only consisted of the entrepreneur of Ihmeiden Kehto. The questionnaire had a scale of 1-10 for each of the chosen criteria: revenue, traveling distance, future potential, and personal enjoyment. The questionnaire also had specific instructions on how to evaluate the criteria and what factors should be taken in consideration when making the evaluation. Additionally, the questionnaire included section where the entrepreneur could add additional criteria, they thought would be important if there were any that were not yet included. This questionnaire is included in Appendix 2.

Additional structured questionnaire form was used when weighting of the criteria and local priorities were done together with the entrepreneur. Sampling for this questionnaire was the same as for the first questionnaire, as the aim of the questionnaire was to gain data specifically from entrepreneur for development of the practical excel-based decision-making tool. This was done by first establishing the importance of criteria in pairwise comparisons to form a pairwise comparison matrix for the Excel tool. Additionally, similar pairwise comparisons were done with the entrepreneur for local priorities of both Excel tools. Data collected from this questionnaire was used in the final development of the excel-based decision-making tool. Findings and results based on the analysis of this data is shown in the next chapter where the development of the Excel tool is explained in detail.

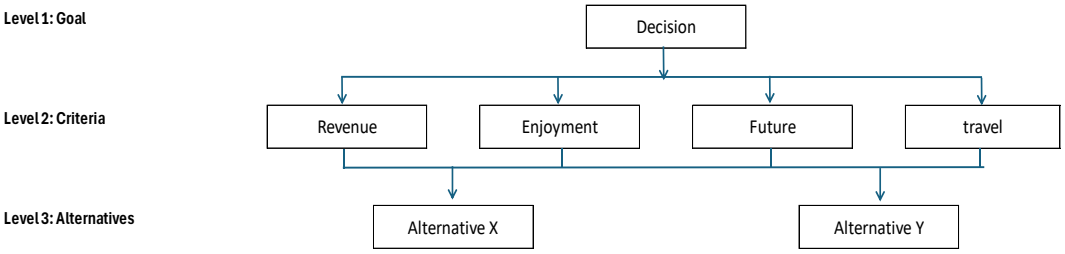
4 Practical Analytic Hierarchy Process tool

This chapter will describe development and implementation of the practical Excel-based decision-making tool that was developed for Ihmeiden Kehto. As in the Analytic Hierarchy Process example shown in the previous chapters, the chapter will start by drawing a decision hierarchy for the decision problem of Ihmeiden Kehto. The chapter will then describe how priorities of important criteria were derived and shows how the entrepreneur can adjust these criteria in the future if it is necessary. After the weighted criteria are established, the chapter will describe two Excel-based decision-making tools that can be used by Ihmeiden Kehto and explain how they were implemented. These Excel-based tools enhance decision-making in two distinct scenarios: when the entrepreneur is deciding between two projects and when the entrepreneur evaluates new projects against past projects. Sensitivity analysis scenarios are provided and explained for both scenarios. The chapter will end with a description of future potential and possible scalability of the tool.

4.1 Decision hierarchy for Ihmeiden Kehto

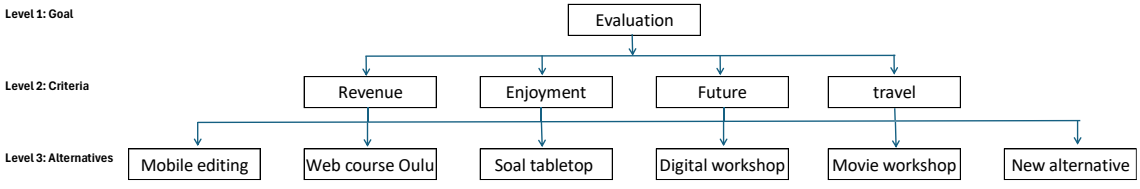
Before a decision hierarchy can be drawn the goal of the process needs to be established. The goal for Ihmeiden Kehto is to evaluate if a potential project is good for the company. The decision is usually done either between two potential projects or by evaluating if a singular project is good for the company. When evaluating singular project, Ihmeiden Kehto compares it to past projects to evaluate how good the project is for the company. The excel-based decision-making tool aims to enhance the decision-making process in these two scenarios by making the comparison and evaluation more efficient and accurate. Based on these decision-making goals, or decision problems, the decision hierarchies can be drawn. First, a decision hierarchy for decisions between two options, which is be called decision between two projects is shown in table 4-1.

Table 4-1: Decision between two projects (Heinonen, 2024)



The first level of the Decision between two projects decision hierarchy is the goal of the project that was to decide between two projects. Second level of the hierarchy is criteria, and it consists of all the criteria that affect decision in the process. As described in the earlier chapters, the important criteria for Ihmeiden Kehto are revenue, enjoyment, future, and travel. The final level of the hierarchy is alternatives, and in this hierarchy, they are the two potential projects that are compared, and as such are named alternative X and alternative Y. A short description of the hierarchy would be a decision between two potential projects done using revenue, enjoyment, future, and travel as decision criteria. The decision hierarchy for the second scenario where the entrepreneur compares a singular potential project to past projects is called Evaluation of a project and is shown in table 4-2.

Table 4-2: Evaluation of a project (Heinonen, 2024)



The first level of Evaluation of a project decision hierarchy is evaluation. In this hierarchy the goal is to evaluate a singular project against other past projects rather than to choose the best alternative. Specifically, the goal is to derive

ranking between the alternatives to determine how high the new project ranks against the chosen projects. Similarly, as in the first scenario, the second level of the hierarchy uses the four chosen important criteria to Ihmeiden Kehto: revenue, enjoyment, future, and travel. In the third level the hierarchy there are six different alternatives. Five of the alternatives are past projects that Ihmeiden Kehto determined to be a good set of projects to use in evaluation of a new project. These five past projects are: Mobile editing, Web course Oulu, Soal tabletop, Digital workshop, and Movie workshop. These are projects that share few important qualities such as they are short term projects that do not require large time commitment and planning times. They were chosen because Ihmeiden Kehto aims to focus on similar projects in foreseeable future. The sixth alternative is called new alternative, and it stands for the new project that is being evaluated. Now that the decision hierarchies have been established, the process can move to the next step: weighting of the important criteria.

4.2 Priorities of important criteria for Ihmeiden Kehto

In this step of the process, priorities are derived from the criteria. Like in the example process provided in the chapter 2.2.2.2 priorities of criteria, the step starts by creating a pairwise comparison matrix that is shown in table 4-3. This was done together with the entrepreneur to gain accurate weights according to their preferences. Without including the decision maker in the pairwise comparison stage of weighting the criteria, the process would not produce accurate results for the decision maker. Pairwise comparison matrix shows that revenue was the most important criterion for Ihmeiden Kehto followed by the enjoyment criterion. Future was less important than these two criteria but moderately more important than travel, which was the least important criterion. This table was then converted to column addition table where a sum was calculated for each column and is shown in table 4-4.

Table 4-3: Ihmeiden Kehto pairwise comparison matrix (Heinonen, 2024)

Decision	Revenue	Enjoyment	Future	Travel
Revenue	1	3	5	8
Enjoyment	1/3	1	5	7
Future	1/5	1/5	1	3
Travel	1/8	1/7	1/3	1

Table 4-4: Ihmeiden Kehto column addition (Heinonen, 2024)

Decision	Revenue	Enjoyment	Future	Travel
Revenue	1,000	3,000	5,000	8,000
Enjoyment	0,333	1,000	5,000	7,000
Future	0,200	0,200	1,000	3,000
Travel	0,125	0,143	0,333	1,000
Sum	1,658	4,343	11,333	19,000

At this point the Excel tool automatically calculates the priorities for the criteria and the consistency ratio that is used to check if the judgements are consistent. If the value of consistency ratio would be over 0,1 some of the judgements would need to be adjusted. The Ihmeiden Kehto judgements, priorities and consistency ratio is shown in table 4-5. This table shows that revenue is the most important criterion for Ihmeiden Kehto with a priority value of 0,539. It is followed be personal enjoyment with priority value of 0,310, meaning that personal enjoyment is influential criterion for Ihmeiden Kehto. Future potential and travel distance received a lower priority value, indicating that they are less influential factors for Ihmeiden Kehto. Although, future and travel have less influence in the process, they may become decisive factors in decisions that have similar importance on revenue and enjoyment factors. It is important that this process is automated in case that the entrepreneur wants to adjust the weighting of the criteria. The tool allows the entrepreneur to simply adjust the judgements and to see the results and if they are consistent. These priorities, or weighted criteria, are later used for both decision-making tools.

Table 4-5: Ihmeiden Kehto judgements, priorities, and consistency ratio (Heinonen, 2024)

Presentation of results: judgements and priorities

Decision	Revenue	Enjoyment	Future	Travel	Priority
Revenue	1,000	3,000	5,000	8,000	0,539
Enjoyment	0,333	1,000	5,000	7,000	0,310
Future	0,200	0,200	1,000	3,000	0,103
Travel	0,125	0,143	0,333	1,000	0,048

Consistency ratio

Consistency Index	0,067
Random Index	0,90
Consistency ratio	0,075

The first of two automations that the tool does is normalization and calculation of priorities. This process works in the same way as in the example process, by first normalizing the pairwise comparison matrix. Normalization of the matrix is done by dividing the judgement value with the sum of the column, and this calculation is repeated for each judgement. Results of these calculation are shown in summary of calculation for priorities table 4-6. The priority of each criterion is calculated by calculating an average of each row of the normalized matrix. Results of these calculation and the priorities, or weights, of the criteria are also shown in the table 4-6.

Table 4-6: Summary of calculations for priorities (Heinonen, 2024)

Normalized matrix

Decision	Revenue	Enjoyment	Future	Travel
Revenue	0,603	0,691	0,441	0,421
Enjoyment	0,201	0,230	0,441	0,368
Future	0,121	0,046	0,088	0,158

Calculation of priorities: row averages

Decision	Revenue	Enjoyment	Future	Travel	Priority
Revenue	0,603	0,691	0,441	0,421	0,539
Enjoyment	0,201	0,230	0,441	0,368	0,310
Future	0,121	0,046	0,088	0,158	0,103
Travel	0,075	0,033	0,029	0,053	0,048

The tool also automatically calculates the consistency ratio, and it is done in the same way as in the example process. A weighted sum value is calculated for each criterion by first multiplying each of the original judgements with their corresponding priority. After this calculation is repeated for each of the original judgements, a sum of each row is calculated. This sum is the weighted sum value, and it is shown in summary of calculation for consistency ratio table 4-7. Consistency index is calculated using $Lambda_{max}$ by firs dividing each of the weighted sum values by their corresponding priority value. A sum of these values is calculated and then divided by the number of criteria used in the process. The value of consistency index is calculated by first dividing the result of $Lambda_{max}$ with the number of criteria used in the process, then subtracting one from the number of criteria used in the process. Then, results of these two calculations are divided by each other. The results of these calculations are also shown in table 4-7.

Table 4-7: Summary of calculation for consistency ratio (Heinonen, 2024)

Priorities as factors

Decision	Revenue	Enjoyment	Future	Travel
Criteria weights	0,539	0,310	0,103	0,048
Revenue	1,000	3,000	5,000	8,000
Enjoyment	0,333	1,000	5,000	7,000
Future	0,200	0,200	1,000	3,000
Travel	0,125	0,143	0,333	1,000

Calculation of weighted sum

Decision	Revenue	Enjoyment	Future	Travel	Weighted sum
Revenue	0,539	0,931	0,516	0,381	2,366
Enjoyment	0,179	0,310	0,516	0,333	1,339
Future	0,108	0,062	0,103	0,143	0,416
Travel	0,067	0,044	0,034	0,048	0,194

Calculation of $Lambda_{max}$

Weighted sum	priority	
2,366	0,539	4,390
1,339	0,310	4,316
0,416	0,103	4,029
0,194	0,048	4,070
	Total	16,805
	Divide by 4	4,201
Consistency index		0,067

Consistency ratio is calculated by dividing the consistency index with the value from randomly generated matrix that is corresponding to the number of criteria that is used in the process. The randomly generated matrix is shown in Random-like matrix table 2-12, and the result for consistency ratio is shown in Ihmeiden Kehto judgements, priorities, and consistency ratio table 4-5. Now that the chapter has described the weighting of the criteria step, it will move to explain the development and implementation of fist of the two Excel tools: decision between two projects.

4.3 Decision between two projects Excel tool

The purpose of Decision between two projects Excel tool is to enable the entrepreneur to efficiently compare and decide between two potential projects. It is a useful tool for the entrepreneur in situations where they can fit only one of the two projects in their schedule and are having difficulties in deciding between them. The Excel tool itself is simple and like the one used as example in the earlier chapters, only difference being that the model uses the four criteria weighted in this chapter instead of three. The Excel tool is efficient to use for the entrepreneur as it only requires them to fill judgements for the local priorities and automates all calculations needed to present the results. The model also includes two automated analysing tools that were explained in the earlier chapters.

To use the Excel tool, the entrepreneur fills the pairwise comparison matrix for local priorities as instructed in the earlier chapters. The comparisons are done between the two projects in relation to a specific criterion and is repeated for all the four criteria. To test the Excel tool, this process was done with the entrepreneur using two projects that Ihmeiden Kehto has done in the past. These projects are called Movie workshop and Mobile editing. Movie workshop is a course that teaches movie editing in Mikkeli, and Mobile editing course teaches video editing with a mobile app in Kangasniemi. Movie workshop has a higher revenue and Mobile editing course is more enjoyable for Ihmeiden Kehto. Movie workshop also has petter possibilities for future but includes more travel. Both projects are better than the other when compared to two criteria and as such the use of the Excel tool can help in deciding between the two. Judgements filled by the entrepreneur are summarised and shown in table 4-8. Judgements of Decision between two projects.

Table 4-8: Judgements of Decision between two projects (Heinonen, 2024)

Comparison with criterion Revenue

Revenue	Movie workshop	Mobile editing
Movie workshop	1,000	4,000
Mobile editing	0,250	1,000
Sum	1,250	5,000

Comparison with criterion Enjoyment

Enjoyment	Movie workshop	Mobile editing
Movie workshop	1,000	0,250
Mobile editing	4,000	1,000
Sum	5,000	1,250

Comparison with criterion Future

Future	Movie workshop	Mobile editing
Movie workshop	1,000	6,000
Mobile editing	0,166	1,000
Sum	1,166	7,000

Comparison with criterion Travel

Travel	Movie workshop	Mobile editing
Movie workshop	1,000	0,250
Mobile editing	4,000	1,000
Sum	5,000	1,250

At this stage, the Excel tool automatically calculates results for the decision between two projects. These calculations are the same as in the example explained in the earlier chapters where first the sum of columns is calculated from the comparison matrix. This is shown in the table 4-8. Then the table is normalized by dividing each of the judgements with the sum of their column. Finally, the priority of each local priority is calculated by calculating an average for each row of the table. A summary of these calculations is shown in table 4-9. Summary of calculation for Decision between two projects. The excel tool is comparing only two alternatives, so a calculation for consistency ratio is not needed. The comparison matrix is always consistent with two alternatives, and if three or more alternatives were compared, a consistency ratio would need to be calculated for each comparison matrix.

Table 4-9: Summary of calculations for Decision between two projects (Heinonen, 2024)

Priority with criterion A

Criterion A	Alternative X	Alternative Y	Priority
Alternative X	0,800	0,800	0,800
Alternative Y	0,200	0,200	0,200

Priority with criterion B

Criterion B	Alternative X	Alternative Y	Priority
Alternative X	0,200	0,200	0,200
Alternative Y	0,800	0,800	0,800

Result with criterion A

Criterion A	Alternative X	Alternative Y	Priority
Alternative X	1,000	4,000	0,800
Alternative Y	0,250	1,000	0,200

Result with criterion B

Criterion B	Alternative X	Alternative Y	Priority
Alternative X	1,000	0,250	0,200
Alternative Y	4,000	1,000	0,800

Priority with criterion C

Criterion C	Alternative X	Alternative Y	Priority
Alternative X	0,858	0,857	0,857
Alternative Y	0,142	0,143	0,143

Priority with criterion D

Criterion D	Alternative X	Alternative Y	Priority
Alternative X	0,200	0,200	0,200
Alternative Y	0,800	0,800	0,800

Result with criterion C

Criterion C	Alternative X	Alternative Y	Priority
Alternative X	1,000	6,000	0,857
Alternative Y	0,166	1,000	0,143

Result with criterion D

Criterion D	Alternative X	Alternative Y	Priority
Alternative X	1,000	0,250	0,200
Alternative Y	4,000	1,000	0,800

Model synthesis is done based on these calculations. At this stage the local priorities derived for each criterion for both projects are compiled to a table. These priorities are then multiplied with their respective criteria weight, which were calculated earlier in this chapter. Finally overall priority is calculated by calculating a sum of the multiplied priorities for each row. The overall priority dictates how a project compares to the other project in the Excel tool. This is shown in table 4-10. Results for Decision between two projects.

Table 4-10: Results for Decision between two projects (Heinonen, 2024)

Overall priorities

	Revenue	Enjoy-ment	Future	Travel	Overall prior-ity
Criteria Weights	0,539	0,310	0,103	0,048	
Movie workshop	0,800	0,200	0,857	0,200	0,591
Mobile editing	0,200	0,800	0,143	0,800	0,409

Results

Alternatives	Overall priority
Movie workshop	0,591
Mobile editing	0,409

Before a final decision, it is recommended that a sensitivity analysis is done to understand why one of the alternatives is better. This excel tool provides two automated analysis tools that are a scenario where all criteria are equal and a scenario where the most important criterion is lowered to a value where the alternatives are of same value and all the other criteria are equal. First scenario helps the decision maker to understand how much and how the weighted criteria affect the model. The second scenario helps the decision maker to understand how much the most important criterion affects the model. These scenarios are shown in table 4-11. Sensitivity analysis for Decision between two projects

Table 4-11: Sensitivity analysis for Decision between two projects (Heinonen, 2024)

Scenario: all criteria have same weight

	Revenue	Enjoyment	Future	Travel	Overall priority
Criteria Weights	0,250	0,250	0,250	0,250	
Alternative X	0,800	0,200	0,857	0,200	0,514
Alternative Y	0,200	0,800	0,143	0,800	0,486

Scenario: Importance of revenue

	Revenue	Enjoyment	Future	Travel	Overall priority
Criteria Weights	0,213	0,262	0,262	0,262	
Alternative X	0,800	0,200	0,857	0,200	0,500
Alternative Y	0,200	0,800	0,143	0,800	0,500

Based on the model synthesis and sensitivity analysis, a final decision can be made. A decision between the two projects used as an example in the Excel tool can be described as follows. With Analytic Hierarchy Process Excel tool, it can be stated that movie workshop is somewhat better than the mobile course. However, if the criteria used to weigh the decision were equal, the movie workshop would be only slightly better than mobile editing and the importance of revenue in the model was 0.213, or 21.3%. With these results, the decision would be to choose movie course if the importance of revenue to the decision is over 21.3%. If the importance of revenue to the decision were less than that, the mobile editing course would be a better option.

4.4 Evaluation of a project Excel tool

The purpose of Evaluation of a project based on past projects Excel tool is to provide the entrepreneur a tool to evaluate a potential project by comparing it to a chosen set of past projects. These projects were chosen by the entrepreneur because they are a good reference point for comparing potential new offers. These projects are called: Mobile editing, Web course Oulu, Soal tabletop, Digital workshop, and Movie workshop. The Excel tool itself works the same way as in the previous tool with the four chosen criteria. Only difference being that this Excel tool uses six alternatives instead of two. Five of these alternatives are the selected past projects, and the sixth one is the potential new project that is being evaluated. In the example analysis presented in this chapter a potential offer called Improv is the sixth alternative that is being evaluated. Use of the Excel tool have been made simple and efficient for the entrepreneur and only requires them to fill pairwise comparisons for the potential new offer.

The first stage of using this Excel tool is to fill judgements of the pairwise comparisons of the alternatives in respect to each criterion. This process was done with the entrepreneur so that the results produced by the Excel tool are accurate for Ihmeiden Kehto. The pairwise judgements are done using same logic and instructions as in the earlier examples. Results of these pairwise judgements are shown in table 4-12 Judgements and consistency of Evaluation of a project.

When the entrepreneur uses this Excel tool the future, they add the name of the evaluated project in the place of Improv project, and the judgements of how the new project compares against the past projects. The cells in the table that the entrepreneur uses in this tool are highlighted with green colour, and the past projects are highlighted with bule colour. As this Excel tool is comparing more than two alternatives, the consistency of the model needs to be checked with consistency ratio. The Excel tool automates this process and shows the results next to each of the pairwise comparison table. The consistency ratio should never exceed a value of 0.1 which would indicate that there are too many inconsistencies in the comparison matrix. If the consistency ratio exceeds the allowed value, the cell that shows said value would change to a red colour. In this case, the entrepreneur would need to adjust the judgements to make the comparison matrix consistent. After the judgements are assigned to the tables in a way that they are consistent, the entrepreneur would move to see the results of the model synthesis as all the calculations in this Excel tool are automated.

Table 4-12: Judgements and consistency of Evaluation of a project (Heinonen, 2024)

Revenue	Mobile editing	Web course Oulu	Soal tabletop	Digital workshop	Movie workshop	Improv
Mobile editing	1,000	1,000	1,000	0,500	0,250	2,000
Web course Oulu	1,000	1,000	1,000	0,500	0,250	2,000
Soal tabletop	1,000	1,000	1,000	0,500	0,250	2,000
Digital workshop	2,000	2,000	2,000	1,000	0,333	3,000
Movie workshop	4,000	4,000	4,000	3,000	1,000	5,000
Improv	0,500	0,500	0,500	0,330	0,200	1,000

Consistency ratio	
Consistency Index	0,009
Random Index	1,24
Consistency ratio	0,008

Enjoyment	Mobile editing	Web course Oulu	Soal tabletop	Digital workshop	Movie workshop	Improv
Mobile editing	1,000	2,000	0,333	5,000	3,000	1,000
Web course Oulu	0,500	1,000	0,250	4,000	2,000	0,500
Soal tabletop	3,000	4,000	1,000	8,000	6,000	3,000
Digital workshop	0,200	0,250	0,125	1,000	0,250	0,200
Movie workshop	0,333	0,500	0,167	2,000	1,000	0,333
Improv	1,000	2,000	0,333	5,000	3,000	1,000

Consistency ratio	
Consistency Index	0,001
Random Index	1,24
Consistency ratio	0,001

Future	Mobile editing	Web course Oulu	Soal tabletop	Digital workshop	Movie workshop	Improv
Mobile editing	1,000	0,333	0,200	0,500	0,250	0,500
Web course Oulu	3,000	1,000	0,333	1,000	0,500	2,000
Soal tabletop	5,000	3,000	1,000	3,000	2,000	6,000
Digital workshop	2,000	1,000	0,333	1,000	0,500	1,000
Movie workshop	4,000	2,000	0,500	2,000	1,000	2,000
Improv	2,000	0,500	0,167	1,000	0,500	1,000

Consistency ratio	
Consistency Index	0,020
Random Index	1,24
Consistency ratio	0,016

Travel	Mobile editing	Web course Oulu	Soal tabletop	Digital workshop	Movie workshop	Improv
Mobile editing	1,000	0,166	0,333	0,250	2,000	0,500
Web course Oulu	6,000	1,000	4,000	5,000	8,000	4,000
Soal tabletop	3,000	0,250	1,000	2,000	3,000	0,333
Digital workshop	2,000	0,200	0,500	1,000	4,000	2,000
Movie workshop	0,500	0,125	0,333	0,250	1,000	0,333
Improv	2,000	0,250	3,000	0,500	3,000	1,000

Consistency ratio	
Consistency Index	0,081
Random Index	1,24
Consistency ratio	0,066

The Excel tool automates the calculations by first calculating a sum for each column as was done in the earlier Excel tool. Then the comparison matrix is normalized by dividing each of the judgements with the sum of their column. Finally, an average is counted for each row to gain a priority value for each

alternative. This process is then repeated for each of the remaining comparison matrixes. Summary of these calculations for revenue criterion are shown in table 4-13 Summary of calculations for Evaluation of a project. After all the judgements are inserted by the entrepreneur, the Excel tool automatically gathers the priority values of each calculation to a table where the entrepreneur can see how the project being evaluated ranked against other projects in respect to each of the criteria. These values are shown in table 4-14 Results of local priorities.

Table 4-13: Summary of calculations for Evaluation of a project (Heinonen, 2024)

Calculation of priorities: Sum of columns

Revenue	Mobile editing	Web course Oulu	Soal tabletop	Digital workshop	Movie workshop	Improv
Mobile editing	1,000	1,000	1,000	0,500	0,250	2,000
Web course Oulu	1,000	1,000	1,000	0,500	0,250	2,000
Soal tabletop	1,000	1,000	1,000	0,500	0,250	2,000
Digital workshop	2,000	2,000	2,000	1,000	0,333	3,000
Movie workshop	4,000	4,000	4,000	3,000	1,000	5,000
Improv	0,500	0,500	0,500	0,330	0,200	1,000
Sum	9,500	9,500	9,500	5,830	2,283	15,000

Calculation of priorities: row averages

Revenue	Mobile editing	Web course Oulu	Soal tabletop	Digital workshop	Movie workshop	Improv	Priority
Mobile editing	0,105	0,105	0,105	0,086	0,110	0,133	0,107
Web course Oulu	0,105	0,105	0,105	0,086	0,110	0,133	0,107
Soal tabletop	0,105	0,105	0,105	0,086	0,110	0,133	0,107
Digital workshop	0,211	0,211	0,211	0,172	0,146	0,200	0,191
Movie workshop	0,421	0,421	0,421	0,515	0,438	0,333	0,425
Improv	0,053	0,053	0,053	0,057	0,088	0,067	0,061

Table 4-14: Results of local priorities (Heinonen, 2024)

Revenue	Mobile editing	Web course Oulu	Soal tabletop	Digital workshop	Movie workshop	Improv	Priority
Mobile editing	1,000	1,000	1,000	0,500	0,250	2,000	0,107
Web course Oulu	1,000	1,000	1,000	0,500	0,250	2,000	0,107
Soal tabletop	1,000	1,000	1,000	0,500	0,250	2,000	0,107
Digital workshop	2,000	2,000	2,000	1,000	0,333	3,000	0,191
Movie workshop	4,000	4,000	4,000	3,000	1,000	5,000	0,425
Improv	0,500	0,500	0,500	0,330	0,200	1,000	0,061

Enjoyment	Mobile editing	Web course Oulu	Soal tabletop	Digital workshop	Movie workshop	Improv	Priority
Mobile editing	1,000	2,000	0,333	5,000	3,000	1,000	0,181
Web course Oulu	0,500	1,000	0,250	4,000	2,000	0,500	0,112
Soal tabletop	3,000	4,000	1,000	8,000	6,000	3,000	0,429
Digital workshop	0,200	0,250	0,125	1,000	0,250	0,200	0,034
Movie workshop	0,333	0,500	0,167	2,000	1,000	0,333	0,064
Improv	1,000	2,000	0,333	5,000	3,000	1,000	0,181

Future	Mobile editing	Web course Oulu	Soal tabletop	Digital workshop	Movie workshop	Improv	Priority
Mobile editing	1,000	0,333	0,200	0,500	0,250	0,500	0,055
Web course Oulu	3,000	1,000	0,333	1,000	0,500	2,000	0,136
Soal tabletop	5,000	3,000	1,000	3,000	2,000	6,000	0,388
Digital workshop	2,000	1,000	0,333	1,000	0,500	1,000	0,113
Movie workshop	4,000	2,000	0,500	2,000	1,000	2,000	0,216
Improv	2,000	0,500	0,167	1,000	0,500	1,000	0,092

Travel	Mobile editing	Web course Oulu	Soal tabletop	Digital workshop	Movie workshop	Improv	Priority
Mobile editing	1,000	0,166	0,333	0,250	2,000	0,500	0,062
Web course Oulu	6,000	1,000	4,000	5,000	8,000	4,000	0,463
Soal tabletop	3,000	0,250	1,000	2,000	3,000	0,333	0,141
Digital workshop	2,000	0,200	0,500	1,000	4,000	2,000	0,140
Movie workshop	0,500	0,125	0,333	0,250	1,000	0,333	0,042
Improv	2,000	0,250	3,000	0,500	3,000	1,000	0,152

Another automated calculation in this Excel tool is the calculation of consistency ratio. This is calculated in the same way when calculating consistency ratio for the priorities of the criteria. Judgements in the original comparison matrix are multiplied with the corresponding local priority values in their column. In other words, each of the original judgements are multiplied with priority values of each of the alternatives. After this is completed, a weighted sum is calculated by

calculating a sum for each of the rows in the table. This weighted sum value is then used to calculate a $Lambda_{max\ value}$. This is calculated by dividing each of the weighted sum values with the priority value of the same criterion. Then a sum of these results is calculated and divided with the number of alternatives that are being compared. Finally, consistency index is calculated by subtracting the number of alternatives from this value and dividing the result with number of alternatives minus one. This process is then repeated for each of the comparison matrixes. These calculations are summarised for the revenue criteria in table 4-15 Calculations for consistency ratio. Then consistency ratio is calculated by dividing the value of consistency with the random-like matrix value. As this Excel tool uses six alternatives, a value for six variables is chosen for the calculation. This value is 1,24 as shown in the table 2-12. The result of this calculation is shown in the table 4-12 next to the original judgements for each criterion.

Table 4-15: Calculations for consistency ratio (Heinonen, 2024)

Priorities as factors

Revenue	Mobile editing	Web course Oulu	Soal tabletop	Digital workshop	Movie workshop	Improv
Local priorities	0,107	0,107	0,107	0,191	0,425	0,061
Mobile editing	1,000	1,000	1,000	0,500	0,250	2,000
Web course Oulu	1,000	1,000	1,000	0,500	0,250	2,000
Soal tabletop	1,000	1,000	1,000	0,500	0,250	2,000
Digital workshop	2,000	2,000	2,000	1,000	0,333	3,000
Movie workshop	4,000	4,000	4,000	3,000	1,000	5,000
Improv	0,500	0,500	0,500	0,330	0,200	1,000

Weighted columns

Revenue	Mobile editing	Web course Oulu	Soal tabletop	Digital workshop	Movie workshop	Improv
Mobile editing	0,107	0,107	0,107	0,096	0,106	0,123
Web course Oulu	0,107	0,107	0,107	0,096	0,106	0,123
Soal tabletop	0,107	0,107	0,107	0,096	0,106	0,123
Digital workshop	0,215	0,215	0,215	0,191	0,141	0,184
Movie workshop	0,430	0,430	0,430	0,574	0,425	0,307
Improv	0,054	0,054	0,054	0,063	0,085	0,061

Weighted sum

Revenue	Mobile editing	Web course Oulu	Soal tabletop	Digital workshop	Movie workshop	Improv	Weighted Sum
Mobile editing	0,107	0,107	0,107	0,096	0,106	0,123	0,647
Web course Oulu	0,107	0,107	0,107	0,096	0,106	0,123	0,647
Soal tabletop	0,107	0,107	0,107	0,096	0,106	0,123	0,647
Digital workshop	0,215	0,215	0,215	0,191	0,141	0,184	1,162
Movie workshop	0,430	0,430	0,430	0,574	0,425	0,307	2,595
Improv	0,054	0,054	0,054	0,063	0,085	0,061	0,371

Calculation of $Lambda_{max}$

weighted sum	Local priority	
0,647	0,107	6,025
0,647	0,107	6,025
0,647	0,107	6,025
1,162	0,191	6,067
2,595	0,425	6,109
0,371	0,061	6,032
	Total	36,283
	Divided by *n*	6,047
Consistency index		0,009

Now that the local priorities are calculated, the model synthesis can be done. Like in the previous Excel tool, the local priorities, and criteria wights are compiled to a table. Then the local priorities are multiplied with the criteria weight of the same column. Finally, a sum is calculated for each row to find the overall priority. The overall priority dictates how the evaluated project compares to the other projects. Results of these calculations are shown in table 4-16 Results of Evaluation of a project.

Table 4-16: Results of Evaluation of a project (Heinonen, 2024)

	Revenue	Enjoyment	Future	Travel	Overall priority
Criteria Weights	0,539	0,310	0,103	0,048	
Mobile editing	0,107	0,181	0,055	0,062	0,123
Web course Oulu	0,107	0,112	0,136	0,463	0,129
Soal tabletop	0,107	0,429	0,388	0,141	0,238
Digital workshop	0,191	0,034	0,113	0,140	0,132
Movie workshop	0,425	0,064	0,216	0,042	0,273
Improv	0,061	0,181	0,092	0,152	0,106

Alternatives	Overall priority
Movie workshop	0,273
Soal tabletop	0,238
Digital workshop	0,132
Web course Oulu	0,129
Mobile editing	0,123
Improv	0,106

Before deciding to accept or decline the new project Improv based on the result from this Excel tool, the entrepreneur will first further analyse the decision using sensitivity analysis. The Excel tool provides an automated scenario that can be used in the analysis. The scenario is one where all the weighted criteria are equal. Using this scenario, the entrepreneur can see what the ranking would be without the criteria weightings and how much the weighting of the criteria affects the decision. Unlike in the previous Excel tool, the second scenario where the dominant criterion is lowered, while all the other criteria are equal to a point where all the alternatives are equal is not practical for this model. As in this this model enjoyment is also a dominant criterion to a point that the equality would not be reached without adjusting the weighting of both criteria. The entrepreneur can use this information in the decision by understanding that if importance of revenue or enjoyment either increases or decreases in the decision, it will have a strong impact on the decision. An empty scenario is provided in the Excel tool to enable the entrepreneur to see the results using their chosen weights for the criteria.

Both scenarios are shown in table 4-16 Sensitivity analysis for Evaluation of a project.

Table 4-17: Sensitivity analysis for Evaluation of a project (Heinonen, 2024)

Scenario: all criteria have same weight

	Revenue	Enjoyment	Future	Travel	Overall priority
Criteria Weights	0,250	0,250	0,250	0,250	
Mobile editing	0,107	0,181	0,055	0,062	0,101
Web course Oulu	0,107	0,112	0,136	0,463	0,205
Soal tabletop	0,107	0,429	0,388	0,141	0,266
Digital workshop	0,191	0,034	0,113	0,140	0,120
Movie workshop	0,425	0,064	0,216	0,042	0,186
Improv	0,061	0,181	0,092	0,152	0,121

Scenario: Sensitivity analysis table for additional scenarios

	Revenue	Enjoyment	Future	Travel	Overall priority
Criteria Weights					
Mobile editing	0,107	0,181	0,055	0,062	0,000
Web course Oulu	0,107	0,112	0,136	0,463	0,000
Soal tabletop	0,107	0,429	0,388	0,141	0,000
Digital workshop	0,191	0,034	0,113	0,140	0,000
Movie workshop	0,425	0,064	0,216	0,042	0,000
Improv	0,061	0,181	0,092	0,152	0,000

Now after the calculations for sensitivity analysis are done, a final decision can be made. The decision is to evaluate the Improv alternative against other alternatives and to decide whether it is a project Ihmeiden Kehto should accept or decline. The Improv ranks poorly against other alternatives leaving it to last place with a ranking of 0,106. This is not too far from the next three alternatives but falls significantly behind the leading alternatives Movie workshop and Soal tabletop. When comparing the alternatives with equal criteria weights in the sensitivity analysis, the weighted criteria affect negatively on the Improv, placing it around middle of the rankings. Even in this scenario, the Improv alternative is notably worse than the top alternatives. Using the second scenario, the Improv performs relatively well in enjoyment criteria and travel criteria. Using this information a following recommendation for the decision is made. The Improv alternative is not comparing well against the other alternatives, but it should be

noted that the weighting of the criteria worsens the ranking it has. It would require a notable increase in importance of enjoyment and travel criterion to the decision to make the Improv an attractive project. This means that Ihmeiden Kehto should decline this project or investigate possibilities to negotiate for a better price for the project.

4.5 Summary of the chapter

In this chapter the thesis describes how the Analytic Hierarchy Process can be used as in decision making in Ihmeiden Kehto. The chapter produces two practical Excel-based tools that utilize the Analytic Hierarchy Process and aid the entrepreneur in their decision-making process. The chapter describes the process by first forming decision hierarchies for both processes, and established criteria weights using the important criteria for Ihmeiden Kehto that were identified in the interview of the entrepreneur. Finally, the chapter describes how these Excel tools work and instructs the entrepreneur how to use them. The chapter further specified the priority of the important criteria by weighting the criteria against each other using the Analytic Hierarchy Process. It was established that Analytic Hierarchy Process can be used by Ihmeiden Kehto to compare two potential offers against each other and to evaluate a potential offer using a set of past projects. The Excel tools were developed in a way that they are easy and efficient to use by automating calculations. Entrepreneur is only required to input judgements for the potential offers to see the results.

The Excel tool is going to be further developed and the aim in first stage is to add more functionalities to the tool. One of these functionalities is a way to document and store results in a table with additional business information such as location, organization, and project type. Aim of this functionality is to build a data base of all past projects that can be used in business analytics. Second planned functionality is user interface and input interface for the Excel-tools that further automates the use of these tools.

5 Conclusion

Objectives of the thesis were to enhance decision-making process in offer evaluations at Ihmeiden Kehto, and the development of Analytic Hierarchy Process based Excel-tool for offer evaluations. The thesis set out to answer four research questions to achieve this objective. Findings of the thesis are next discussed based on these research questions.

First stated research question was what are Ihmeiden Kehto's priorities when selecting new projects? Based on an interview with the entrepreneur of Ihmeiden Kehto four important factors were identified in their decision-making. These important factors were revenue, future potential, personal enjoyment and travel distance. Based on a questionnaire filled by the entrepreneur of Ihmeiden Kehto, and the weighting of criteria, or priorities of criteria, in the excel tool, it was established that revenue has the highest priority for Ihmeiden Kehto when selecting new projects. Personal enjoyment was identified to be the second priority when selecting new projects. Future potential of a project and travel distance to the location of a project had lower priority on the selection of a project but were still important factors in the decision-making. These four criteria were chosen to be used in the Excel-based tool based on the interview, questionnaires and supporting secondary data.

Second research question was how does the Analytic Hierarchy Process function as a decision-making methodology? The thesis was able to establish that Analytic Hierarchy Process is a structured decision-making method that would fit well to the needs of Ihmeiden Kehto because it enables comparisons of tangible and intangible values. This functionality is enabled by deriving ratio scales for the criteria and variables using pairwise comparison matrix. Analytic Hierarchy Process consists of six stages first of which is creation of a decision hierarchy where the decision problem, factors that impact the decision and possible outcomes of the decision are defined. Second stage is weighting of criteria where decision criteria are compared against each other in a pairwise comparison matrix. Third stage is to check the consistency of the comparison matrix. Fourth

stage is to compare the possible outcomes of the decision against each other and the decision criteria in a pairwise comparison matrix to form local priorities. Fifth stage is to perform model synthesis by using the weighted criteria and local priorities. The overall priority, or the results of the process are formed in this stage. The sixth stage of the process is to perform sensitivity analysis to understand how weighted criteria affect the decision and to form the final decision.

Third research question was what are the advantages and limitations of Analytic Hierarchy Process? The main advantage of Analytic Hierarchy Process is that it enables the comparison of criteria with tangible and intangible values. This was important functionality because the Excel-based decision-making tool made for Ihmeiden Kehto compares criteria with different types of values. This means that the Analytic Hierarchy Process enables the comparison of personal enjoyment and future potential to revenue and travel distance. Limitations of Analytic Hierarchy Process that were identified were the final decision dependent on the professional expertise of the decision-maker, and that it cannot automatically make the decision for the decision-maker. The Analytic Hierarchy process is also sensitive to changes in circumstances and preferences. The Excel-based decision-tool developed in this thesis relies on that the decision-maker takes these factors in consideration when using it.

The final research question was in what way can the analytic hierarchy process be used to consider offers on new projects in Ihmeiden Kehto? The thesis documented the development of an Excel-based decision-making tool that uses Analytic Hierarchy Process and was tailored specifically for Ihmeiden Kehto. The Excel-tool enables Ihmeiden Kehto to consider offers on new projects in two distinct scenarios. These scenarios are decision made between two potential projects and evaluation of a singular potential project against a set of past projects. These Excel-tools are fully automated and only requires the entrepreneur at Ihmeiden Kehto to input judgements for the pairwise comparison matrix for the projects that they are comparing or evaluating.

The findings of this thesis are tailored specifically to the needs of Ihmeiden Kehto and as such are of limited use of other organizations businesses operating in the field. However, the Analytic Hierarchy Process theory presented in this thesis can be of use to other organizations businesses in the field. Important criteria would need to be selected to according to the needs and goals of the business or organization. Decision hierarchies would need to be drawn to describe the specific decision that is being made with the decision goal, criteria and potential outcomes of the decision.

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Ihmeiden Kehto Interview

Question: Could you start by telling me what type of business Ihmeiden Kehto is and what type of products and services it provides?
Ihmeiden Kehto Entrepreneur: Sure, Ihmeiden Kehto private entrepreneurship and focus of the business has lately been various theatre courses and movie themed courses. Like short movies, editing courses and so on. I have also recently branched out on web courses. But as private entrepreneur I can provide many interesting courses, like a tabletop roleplaying course that have been running for several years. I offer the courses mostly on local schools and civic collages Mikkeli and surrounding area. I have recently also started branching out on web courses.
Question: What is the decision-making process of choosing new projects like for Ihmeiden Kehto?
Ihmeiden Kehto Entrepreneur: Well, as an entrepreneur, money is really something that wights on that decision a lot. I also consider travel distance and if the organization offering the project is likely to offer more projects. Or if the project is good for networking. I would also want to weight how much I like the project on the decision, but that part still needs some work.
Question: Can you tell me more how you evaluate how well the project pays? Is it total revenue for the project or course or time for period or something else? Also, what kind of costs effect the evaluation of payment for the project?
Ihmeiden Kehto Entrepreneur: When I am negotiating a price for a course or project it is usually done as the payment for the whole project. But internally I evaluate the projects by estimated hourly pay. This includes active hours, preparation, and planning and in some cases editing. Travel is one of the higher costs, but I usually evaluate it separately as I don’t mind driving to the location that much. Any specific course rarely has costs that are not in some way compensated.

Question: Would you think that it would be better to use hourly pay to evaluate offers in the Excel tool that I am making for the thesis, or would you prefer to use the payment for the whole project in the evaluation?
Ihmeiden Kehto Entrepreneur: Hourly pay is much easier to compare so I think that would be better. As some of the projects last about a year and some projects just for a week. So, I think it might be difficult to compare these projects that way.
Question: Could you expand on how travel distance influences the decision-making process in Ihmeiden Kehto?
Ihmeiden Kehto Entrepreneur: How I think about it is that if the travel distance takes way over hour to drive, the project would need to pay really well or be really interesting. The travel doesn't really influence the decision that much put it surely is part of the decision.
Question: Okay, then how about how likely the project results in future opportunities?
Ihmeiden Kehto Entrepreneur: Well, its influences the decision more than travel but not as much as pay. Maybe a good way to put it would be that if a project is "too good to decline" I would accept it even if the pay was not that good or if the project would not really something I would enjoy doing. Like a difficult project with an organization, I have not worked with yet but could result in many new possibilities.
Question: Then you also mentioned how much you like a project being an influencing factor. Could you tell me more about that?
Ihmeiden Kehto Entrepreneur: Sure, as a private entrepreneur I use large portion of the day with these projects, and I would like to prioritize on projects that I find enjoyment. Like for example video courses for elementary school aged kids pay well but it really is not something I would prefer to do. My aim is that how much I like a project or course would have a big influence for the decision. Maybe not as much as money but close.
Question: Is there anything else that influences the decision on which courses or projects to accept?
Ihmeiden Kehto Entrepreneur: Well only thing that comes to mind right now is if I can fit the course on my schedule. If I already have a project In Kangasniemi for Saturdays mornings on a given month I can't take new course for the same time in Mikkeli. Tough, I don't know if that is something we need to consider here as if a course is not possible to be done, then that is it and I would have to decline it.

Ihmeiden Kehto Questionnaire

Introduction: This questionnaire aims to gather insight on how business offers **Introduction:** This questionnaire aims to gather insight on how business offers are evaluated in Ihmeiden Kehto. The feedback will be used to prioritize various criteria for decision/making.

Criteria Evaluation:

For each of the following criteria, please rate its importance to you in scale 1 to 10 when evaluating offers (1 = Not important. 10 = Utmost important). Please refer to criteria evaluation instructions when rating the importance (scoring instructions appendix).

1. **Revenue** of the offer:

1	2	3	4	5	6	7	8	9	10
							x		

2. **Travel** Required for the offered project:

1	2	3	4	5	6	7	8	9	10
		x							

3. **Future** potential of the project (potential for long-term partnership, growth):

1	2	3	4	5	6	7	8	9	10
				x					

4. **Personal Enjoyment** derived from the project:

1	2	3	4	5	6	7	8	9	10
					x				

Criteria Evaluation instructions

Please rate the importance of each criterion using the scale provided below. Consider the definition of each number before answering to ensure accuracy in the response.

- 1: Not important – This criterion is not important in the decision making-process.
- 2-3: Slightly important – This criterion has some influence in the decision-making but is not a deciding factor.
- 4-5: Moderately important – This criterion is neither major nor minor factor on the decision-making process.
- 6-7: Very important – This criterion has a strong influence in the decision-making process but is not the only deciding factor.
- 8-9: Extremely important – This criterion overshadows most other factors.
- 10: Utmost importance – This criterion is a deciding factor. The decision-making process is heavily influenced on this criterion.

As you rate, please think how each criterion impacts the decision-making process. Be as objective as possible, basing your rating on facts and experiences rather than assumptions.

Ihmeiden Kehto Business Data

Pvm.	Työ	h	Osa-alue	Kurssi tai muu täsmentävä tieto
1.8.	yhteys otavaan ja pelaajiin	60,00 €	Kurssisuunnittelu	soalin varjo
3.8.	etäpeliin pelaajia	120,00 €	Markkinointi	soalin varjo
4.8.	mobiilivideomainosvideo	150,00 €	Markkinointi	mobiilivideo mikkeli
5.8.	mobiilivideomainos	270,00 €	Markkinointi	mobiilivideo mikkeli
8.8.	pelisuunnittelu - tekniset tarpeet	240,00 €	Kurssisuunnittelu	soalin varjo
9.8.	pelisuunnittelu	240,00 €	Kurssisuunnittelu	soalin varjo
10.8.	pelisuunnittelu	120,00 €	Kurssisuunnittelu	soalin varjo
11.8.	pelisuunnittelu, santun paltsu	180,00 €	Kurssisuunnittelu	soalin varjo
15.8.	pelisuunnittelu	300,00 €	Kurssisuunnittelu	soalin varjo
16.8.	pelisuunnittelu etäpeli	270,00 €	Kurssisuunnittelu	soalin varjo
17.8.	pelisuunnittelu	120,00 €	Kurssisuunnittelu	soalin varjo
18.8.	pelisuunnittelu	240,00 €	Kurssisuunnittelu	soalin varjo
19.8.	pelisuunnittelu	120,00 €	Kurssisuunnittelu	soalin varjo
19.8.	soal etä	300,00 €	kurssi tai työ	soalin varjo
20.8.	soal etä	60,00 €	kurssi tai työ	soalin varjo
21.8.	soal etä	300,00 €	kurssi tai työ	soalin varjo
29.8.	pelisuunnittelu	60,00 €	Kurssisuunnittelu	soalin varjo
12.9.	mobiilivideosuunnittelu	36,00 €	Kurssisuunnittelu	mobiilivideo mikkeli

13.9.	mobiilivideosuunnittelu	45,00 €	Kurs-sisuunnit-telu	mobiilivideo mikkeli
13.9.	mobiilivideosuunnittelu	45,00 €	Kurs-sisuunnit-telu	mobiilivideo mikkeli
15.9.	mobiilivideovalmistelu	80,00 €	Kurs-sisuunnit-telu	mobiilivideo mikkeli
16.9.	mobiilivalmistelu	75,00 €	Kurs-sisuunnit-telu	mobiilivideo mikkeli
17.9.	mobiilivalmistelu	60,00 €	Kurs-sisuunnit-telu	mobiilivideo mikkeli
17.9.	mobiilivideokurssi	360,00 €	kurssi tai työ	mobiilivideo mikkeli
18.9.	mobiilivalmistelu	30,00 €	Kurs-sisuunnit-telu	mobiilivideo mikkeli
18.9.	mobiilivideokurssi	360,00 €	kurssi tai työ	mobiilivideo mikkeli
20.9.	ropemarkkinointi	30,00 €	Markki-nointi	soalin varjo
20.9.	soalpelimarkkinointi	40,00 €	Markki-nointi	soalin varjo
23.9.	improkurssin valmistelu	40,00 €	Kurs-sisuunnit-telu	improkurssi mikkeli
23.9.	latvala viimein kiinni, uusia aikoja aletaan hieroa	10,00 €	Kurs-sisuunnit-telu	elokuvapajat
24.9.	improkurssin valmistelu	30,00 €	Kurs-sisuunnit-telu	improkurssi mikkeli
24.9.	improkurssi	369,00 €	kurssi tai työ	improkurssi mikkeli
25.9.	improkurssin valmistelu	30,00 €	Kurs-sisuunnit-telu	improkurssi mikkeli
25.9.	improkurssi	240,00 €	kurssi tai työ	improkurssi mikkeli
26.9.	kurssikirje pelaajille soal	30,00 €	Kurs-sisuunnit-telu	soalin varjo
27.9.	soal suunnittelu	120,00 €	Kurs-sisuunnit-telu	soalin varjo
28.9.	soal pelin rakentaminen	120,00 €	Kurs-sisuunnit-telu	soalin varjo
29.9.	soal pelin rakentaminen	120,00 €	Kurs-sisuunnit-telu	soalin varjo
30.9.	soalvalmistelu	60,00 €	Kurs-sisuunnit-telu	soalin varjo

30.9.	ajot otava	45,00 €	ajo	soalin varjo
30.9.	soal	300,00 €	kurssi tai työ	soalin varjo
1.10	soal	600,00 €	kurssi tai työ	soalin varjo
1.10.	otava-ajo	60,00 €	ajo	soalin varjo
2.10.	soal	300,00 €	kurssi tai työ	soalin varjo
2.10.	otava-ajo	60,00 €	ajo	soalin varjo
12.10.	videopajat, ajat kalenteriin, ketä mukana	30,00 €	kurssisuunnittelu	elokuvapajat
12.10.	soal seuraavan pelin järjestämistä	30,00 €	kurssisuunnittelu	soalin varjo
9.11.	improsuunnittelu	30,00 €	kurssisuunnittelu	improkurssi mikkeli
10.11.	improkurssin suunnittelu (uutta settiä tulossa paljon, joten tavallaan tämäkin eikertakäyttöistä)	120,00 €	kurssisuunnittelu	improkurssi mikkeli
16.11.	improvalm, tämä myös jatkoa varten tehtyä materiaalia	300,00 €	kurssisuunnittelu	improkurssi mikkeli
17.11.	videopajat valm	60,00 €	kurssisuunnittelu	elokuvapajat
17.11.	improvalm	20,00 €	kurssisuunnittelu	improkurssi mikkeli
18.11.	improvalm	60,00 €	kurssisuunnittelu	improkurssi mikkeli
19.11.	improkurssi	360,00 €	kurssi tai työ	improkurssi mikkeli
19.11.	improvalm.	20,00 €	kurssisuunnittelu	improkurssi mikkeli
20.11.	improkurssi	240,00 €	kurssi tai työ	improkurssi mikkeli
20.11.	improvalm.	20,00 €	kurssisuunnittelu	improkurssi mikkeli
20.11.	impromatkat	40,00 €	ajo	improkurssi mikkeli
21.11.	videopajat 2kpl	180,00 €	kurssi tai työ	elokuvapajat
21.11.	videopajat matkat	70,00 €	ajo	elokuvapajat
23.11.	videopaja	90,00 €	kurssi tai työ	elokuvapajat
23.11.	vidopajamatkat	80,00 €	ajo	elokuvapajat
24.11.	videopaja	180,00 €	kurssi tai työ	elokuvapajat
24.11.	vidopajamatkat	20,00 €	ajo	elokuvapajat
28.11.	elokuvapajat	180,00 €	kurssi tai työ	elokuvapajat
28.11.	elokuvapajat matkat	40,00 €	ajo	elokuvapajat
28.11.	elokuvapajavalmistelu (kameralataukset, pakkaukset ym.)	20,00 €	kurssisuunnittelu	elokuvapajat
30.11.	videopajavalm	20,00 €	kurssisuunnittelu	elokuvapajat

30.11.	videopajat	180,00 €	kurssi tai työ	elokuvapajat
30.11.	videopaja matkat	40,00 €	ajo	elokuvapajat
1.12.	videopajat	180,00 €	kurssi tai työ	elokuvapajat
1.12.	videopajat matkat	40,00 €	ajo	elokuvapajat
7.12	soal pelikuvaus	30,00 €	kurssisuun-nittelu	soalin varjo
12.12.	videopajat	180,00 €	kurssi tai työ	elokuvapajat
12.12.	videopaja-ajot	80,00 €	ajo	elokuvapajat
14.12.	videopajat	180,00 €	kurssi tai työ	elokuvapajat
14.12.	videopajat matkat	20,00 €	ajo	elokuvapajat
15.12.	videopajat	180,00 €	kurssi tai työ	elokuvapajat
15.12.	videopajat matkat	50,00 €	ajo	elokuvapajat
9.1.	soal pelaajatilanne jne.	30,00 €	Markki-nointi	soalin varjo
13.1.	soal valm	30,00 €	kurssisuun-nittelu	soalin varjo
14.1.	rope tarinaa alkuun	30,00 €	kurssisuun-nittelu	soalin varjo
15.1.	kutosten videopajojen pakkaus	30,00 €	kurssisuun-nittelu	elokuvapajat
16.1.	videopajat	180,00 €	kurssi tai työ	elokuvapajat
16.1.	videopajamatkat	70,00 €	ajo	elokuvapajat
16.1.	klipit opeille, kameroiden lataus	20,00 €	kurssisuun-nittelu	elokuvapajat
18.1.	videopaja	90,00 €	kurssi tai työ	elokuvapajat
18.1.	videopajamatkat	40,00 €	ajo	elokuvapajat
18.1.	videopaja pakkaus, lataus, klipit jakoon	30,00 €	kurssisuun-nittelu	elokuvapajat
18.1.	ropesuunnittelu	30,00 €	kurssisuun-nittelu	soalin varjo
19.1.	Elokuvapajat	180,00 €	kurssi tai työ	elokuvapajat
19.1.	Elokuvapajat matkat	40,00 €	ajo	elokuvapajat
19.1.	elokuvapajat purku, lataus ym.	40,00 €	kurssisuun-nittelu	elokuvapajat
22.1.	rope suunnittelu	180,00 €	kurssisuun-nittelu	soalin varjo
23.1.	videopajat	180,00 €	kurssi tai työ	elokuvapajat
23.1.	videopajamatkat	40,00 €	ajo	elokuvapajat
23.1.	ropesuunnittelu	180,00 €	kurssisuun-nittelu	soalin varjo

24.1.	ropesuunnittelu	180,00 €	kurssisuun-nittelu	soalin varjo
25.1.	videopajat	180,00 €	kurssi tai työ	elokuvapajat
25.1.	videopajamatkat	40,00 €	ajo	elokuvapajat
26.1.	videopajat	180,00 €	kurssi tai työ	elokuvapajat
26.1.	videopajamatkat	40,00 €	ajo	elokuvapajat
26.1.	ropesuunnittelu	60,00 €	kurssisuun-nittelu	soalin varjo
27.1.	soal	300,00 €	kurssi tai työ	soalin varjo
27.1.	soal matkat	70,00 €	ajo	soalin varjo
28.1.	soal	600,00 €	kurssi tai työ	soalin varjo
28.1.	soal matkat	70,00 €	ajo	soalin varjo
29.1.	soal	300,00 €	kurssi tai työ	soalin varjo
29.1.	soal matkat	70,00 €	ajo	soalin varjo
30.1.	elokuvapaja	90,00 €	kurssi tai työ	elokuvapajat
30.1.	videopajamatkat	40,00 €	ajo	elokuvapajat
2.2.	elokuvapaja	90,00 €	kurssi tai työ	elokuvapajat
2.2.	videopajamatkat	40,00 €	ajo	elokuvapajat
7.3.	soal pelikuvaus viestit	30,00 €	kurssisuun-nittelu	soalin varjo
11.4.	soalia alkuun, pelipäiväkirjan luku	30,00 €	kurssi tai työ	soalin varjo
14.4.	soalsuunn	120,00 €	kurssi tai työ	soalin varjo
17.4.	ropoesuunn.	30,00 €	kurssi tai työ	soalin varjo
26.4.	heinolavalmistelu	20,00 €	kurssi tai työ	heinola lasten mobiili
27.4.	soalvalmistelu	150,00 €	kurssi tai työ	soalin varjo
27.4.	heinola pack	30,00 €	kurssi tai työ	heinola lasten mobiili
28.7.	heinolamobiili	270,00 €	kurssi tai työ	heinola lasten mobiili
28.7.	heinolamobiili ajot	140,00 €	ajo	heinola lasten mobiili
29.7.	heinolamobiili	270,00 €	kurssi tai työ	heinola lasten mobiili
29.7.	heinolamobiili ajot	140,00 €	ajo	heinola lasten mobiili
2.5.	soalvalmistelu	120,00 €	kurssi tai työ	soalin varjo

3.5.	soalvalmistelu	60,00 €	kurssi tai työ	soalin varjo
4.5.	ropevalm	240,00 €	kurssi tai työ	soalin varjo
5.5.	soalvalmistelu	120,00 €	kurssi tai työ	soalin varjo
5.5.	soal	300,00 €	kurssi tai työ	soalin varjo
5.5.	soalmatkat	70,00 €	ajo	soalin varjo
6.5.	soal	600,00 €	kurssi tai työ	soalin varjo
6.5.	soalmatkat	70,00 €	ajo	soalin varjo
7.5.	soal	300,00 €	kurssi tai työ	soalin varjo
7.5.	soalmatkat	70,00 €	ajo	soalin varjo
17.6.	soal pelikuvaus	30,00 €	kurssi tai työ	soalin varjo
3.8.	ropevalm	30,00 €	kurssi tai työ	soalin varjo
6.8.	ropemark	30,00 €	kurssi tai työ	soalin varjo
7.8.	ropemark	40,00 €	kurssi tai työ	soalin varjo
10.8.	soalsuunn	50,00 €	kurssi tai työ	soalin varjo
12.8.	soalsuunn	50,00 €	kurssi tai työ	soalin varjo
14.8.	rope	150,00 €	kurssi tai työ	soalin varjo
15.8.	rope	120,00 €	kurssi tai työ	soalin varjo
16.8.	rope	120,00 €	kurssi tai työ	soalin varjo
17.8.	rope	120,00 €	kurssi tai työ	soalin varjo
18.8.	rope suunn ja peli	480,00 €	kurssi tai työ	soalin varjo
19.9.	rope	600,00 €	kurssi tai työ	soalin varjo
20.9.	rope	300,00 €	kurssi tai työ	soalin varjo
18.8.	ropemat	70,00 €	ajo	soalin varjo
19.8.	ropemat	70,00 €	ajo	soalin varjo
20.8.	ropemat	70,00 €	ajo	soalin varjo
25.8.	soalsuunn uutta seikkailua, pelin järkkäystä	60,00 €	kurssi tai työ	soalin varjo
28.8.	rope	60,00 €	kurssi tai työ	soalin varjo
27.8.	rope satunnaiset tapahtumat	60,00 €	kurssi tai työ	soalin varjo

2.10.	ropesuunn	60,00 €	kurssi tai työ	soalin varjo
5.10.	ropevalm	40,00 €	kurssi tai työ	soalin varjo
5.10.	elokuvapajavalm	60,00 €	kurssi tai työ	elokuvapajat
5.10.	soalsuunn.	60,00 €	kurssi tai työ	soalin varjo