Tutorial Letter 301/0/2024

Software Project Management

INF3708

Year Module(s)

DEPARTMENT OF INFORMATION SYSTEMS

IMPORTANT INFORMATION

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1. INTRODUCTION

Greetings students. In this tutorial letter, I discuss payback period analysis with the aim of helping you answer payback period-related questions in Assessment 2. I also address uncertainty and errors related to questions that focus on return on investment and the activity-on-node diagram.

2. Payback Analysis

The payback period is the length of time it takes to recover the investment cost or reach the break-even point. The payback period essentially estimates the time that elapses before the benefits (profits) accrued exceed the continuing expenses incurred. This is why the payback period is typically expressed in years. The payback period can help project managers choose between different projects that are similar. The project that yields the shortest payback period is chosen in most cases. An example of choosing which of two similar investments to pursue based on the payback period is discussed under the subheading "Payback Formula for Consistent Cash Flows" later in this document. This tutorial letter will first examine the explanation of the payback analysis provided by Schwalbe (2019) on page 166. I then present an analysis of payback for consistent and varying cash flows by Tincher (2023).

2.1. Schwalbe's Payback Analysis

Schwalbe refers to Figure 4-5 (see below) on page 164 to explain the calculations that underpin the break-even point.

Discount rate	**8%**					
Assume the project is completed in Year 0			**Year**			
	0	**1**	**2**	**3**	**Total**	
Costs	140,000	40,000	40,000	40,000		
Discount factor	1	0.93	0.86	0.79		
Discounted costs	**140,000**	**37,200**	**34,400**	**31,600**	**243,200**	
Benefits	0	200,000	200,000	200,000		
Discount factor	1	0.93	0.86	0.79		
Discounted benefits	**0**	**186,000**	**172,000**	**158,000**	**516,000**	
Discounted benefits - costs	(140,000)	148,800	137,600	126,400	**272,800**	← **NPV**
Cumulative benefits - costs	(140,000)	8,800	146,400	272,800		
		↑				
ROI →	**112%**					
		Payback in Year 1				

FIGURE 4-5 JWD Consulting net present value and return on investment example

My interpretation of Schwalbe's payback analysis in FIGURE 4-5 is based on Figure 1 below. Figure 1 is an Excel formula-driven adaptation of FIGURE 4-5 for the purpose of supporting this tutorial's payback analysis.

	A	B	C	D	E	F	G
1	Discount rate	8%					
2	Assume the project is completed in Year 0			Year			
3		0	1	2	3	Total	
4	Costs	140000	40000	40000	40000		
5	Discount factor	1	0.93	0.86	0.79		
6	**Discounted costs**	**140000**	**37200**	**34400**	**31600**	**243200**	
7							
8	Benefits	0	200000	200000	200000		
9	Discount factor	1	0.93	0.86	0.79		
10	**Discounted benefits**	**0**	**186000**	**172000**	**158000**	**516000**	
11							
12	Cumulative benefits	-140000	148800	137600	126400	**272800**	◄ NPV
13	Cumulative profit	-140000	*8800*	146400	272800		
14			▲				
15			Payback in Year 1				
16							
17	**ROI**	**112%**					

Figure 1: An Excel spreadsheet recreation of FIGURE 4-5.

Schwalbe starts by calculating the cumulative benefits (CB) for each year. For Year 0, the CB, of course, is -140,000 because Year 0 is the year of investment; needless to state, no benefits will be generated in the year of investment. To calculate the CB for each year, the discounted benefits (DB) are deducted from the discounted costs (DC). The formula is as follows: CB = DB – DC. The CB for Year 0 is -140,000, i.e., 0 – 140,000. In Excel (Figure 1), the CB displays in cell B12 and was calculated as follows: =B10–B6. The CB for Year 1 is 148,800. This positive CB suggests that benefits will be generated in Year 1. In Excel, the CB for Year 1 displays in cell C12 and was calculated as follows: =C10–C6. The CBs for Years 2 and 3 were calculated the same way.

Schwalbe then calculates the cumulative profit (CP), which gives an indication of when the payback year is. As expected, the CP for Year 0 is a negative value: -140,000. The calculation is as simple as adding the CB of Year 0 to zero (0). Zero, of course, denotes that zero benefits were generated in Year 0. Therefore, the calculation looks as follows: -140,000 + 0. In Excel, the CP for Year 0 displays in cell B13 and was calculated as follows: =B12 + 0. Year 1, however, returns a positive CP of 8,800. The positive CP was calculated by adding the cumulative profit of Year 0 – which is, of course, not a profit, hence being -140,000 – to the cumulative benefit of Year 0, which is 148,800. Therefore, the calculation looks as follows: -140,000 + 148,800 = 8,800. In Excel, the CP for Year 1 displays in cell C13 and was calculated using the following formula: =B13+C12. Because the CP for Year 1 is positive, the payback occurs in Year 1.

2.2. Payback Analysis for Consistent and Varying Cash Flows

Payback analysis generally comprises a payback formula for consistent cash flows and a payback formula for varying cash flows (Tincher, 2023). Below, I first give an overview of the payback formula for consistent cash flows, followed by an overview of the payback formula for varying cash flows.

Payback Formula for Consistent Cash flows

This payback formula is appropriate for projects that anticipate a consistent cash flow over the project period. Consider a swing trader who purchases a trading bot to help them trade currencies, Forex, crypto, metals, and other markets. The swing trader purchases the bot for R5,850.00 and deposits a fee of R2,000.00 that the bot invests into the markets. Depending on the version and the skill of the trader, bots typically generate constant monthly profits. So, if the bot, for example, generates R1,000.00 in revenue per month, the calculation would be as follows:

R7,850.00/R1,000.00 = a payback period of 7.85 months.

The trader might decide to purchase a more expensive bot worth R6,500.00, which they expect to generate R1,300.00 per month in revenue following a trade deposit of R2,000.00. The calculation would be:

R8,500.00/R1,300.00 = a payback period of 6.54 months.

It might be a better choice to purchase the bot worth R6,500.00 since it might produce a shorter payback period.

Payback Formula for Varying Cash Flows

As stated earlier, this payback formula is appropriate if cash flows vary annually. An example of a project with varying annual cash flows is the design of a subscription platform. Consider an e-entrepreneur who decides to invest in the design of a streaming service to compete against the likes of Netflix and Showmax. In Year 0, they are considering investing R100,000 in building the streaming platform. The e-entrepreneur expects the cash flow to increase annually as more people subscribe to their streaming service. The expected cash flows are illustrated in Table 1 below:

Table 1: Annual cash flow

Year	Cash flow
Year 0	-R100 000.00
Year 1	R20 000.00
Year 2	R32 000.00
Year 3	R59 000.00
Year 4	R80 000.00

To determine the payback year, annual cumulative cash flow must be calculated. In other words, adding up all the cash flows since the inception of the project. See Table 2 below.

Table 2: Annual Cumulative Cash flow

Year	Cash flow	Cumulative cash flow	Calculation of cumulative cash flow
Year 0	-R100 000.00	-R100 000.00	"0 + -R100 000.00 = -R100 000.00"
Year 1	R20 000.00	-R80 000.00	"-R100 000.00 + R20 000.00 = -R80 000.00"
Year 2	R32 000.00	-R48 000.00	"-R80 000.00 + R32 000.00 = -R48 000.00"
Year 3	R59 000.00	R11 000.00	"-R48 000.00 + R59 000.00 = R11 000.00"
Year 4	R80 000.00	R91 000.00	"R11 000.00 + R80 000.00 = R91 000.00"

From Table 2 it can be observed that the payback year start at the end of Year 2 because Year 2 is the last year with a negative cash flow. Although the payback starts at the end of Year 2, it must be determined how far into the next year (how many months into the next year) it takes to fully recoup the initial investment. The formula below can determine the exact year and month:

Payback period = the last year with negative cash flow - (cumulative cash flow at the end of that year/ cash flow during the year after that year)

2 - (-R48,000.00 / R59,000.00)

The payback period is 2.8 (2 years and 8 months).

Why include the last year (Year 2) with a negative cash flow in the calculation?

By the end of Year 2, the cumulative clash flow becomes positive, indicating the point at which the investment transitions from negative to positive.

Why divide 'cumulative cash flow at end of the last year with negative cash flow' by 'the cash flow during the end year after that year'?

The division helps to determine how far into the next year (Year 3 in this case) it takes to fully recover the initial investment. By dividing -R48 000.00 by R59 000.00 (cash flow in Year 3), the fraction of Year 3 to cover the remaining shortfall is calculated: -R48 000.00/R59 000.00 = -0.81.

Why subtract the fraction of Year 3 from the last year with a negative cash flow?

The payback period needs to account for the full years up to the point before the investment is fully recovered, plus the fraction of the next year required to achieve full recovery. Since the result is still negative following cumulative cash flow divided by the fraction by the end of Year 2, we subtract it from 2 (Year 2) to reach a positive cumulative cash flow.

3. Return on Investment

Like the payback period, ROI can also give an indication of whether a project should be launched or inform the decision of choosing between two projects. Return on investment (ROI) is a measure of the benefits a project will return in relation to its investment costs (Beattie, 2024). If the ROI calculation returns a positive value, that means the net returns produce positive earnings; if a negative value is returned, that means the total expenses exceed the total returns. One of your classmates sent me an email about the return on investment (ROI)-related questions that focus on Projects Y and Z in Assessment 2. The student argues that the ROI-related questions should be clear on whether basic or annualised ROI should be calculated. I responded that I expect students to deploy the annualised ROI formula based on the given information (I will return to this observation momentarily). In the subsections below, I first discuss basic ROI and then annualized ROI. Furthermore, I explain why the annualised ROI formula should be deployed to calculate the ROI of Projects Y and Z.

3.1. Basic ROI

The formula for ROI is:

ROI = Net income / Cost of investment

The basic formula is primarily used to calculate the ROI of projects with repeated expenses and once-off returns. As an example, consider the Netflix show "Rust Valley Restorers":

> "Old-school auto collector Mike Hall, his pal Avery Shoaf and son Connor Hall go the extra mile to restore retro cars -- and hopefully turn a profit." (Netflix, 2019)

Mechanics and old-school auto restorers typically buy old and broken vehicles cheaply, fix and restore them, and then sell them at a profit where the net return significantly exceeds the cost of buying and restoring them. For instance, if they purchase an old car with mechanical faults valued at R20,000, fix, and restore it at additional costs of R30,000, and sell it for R120,000 two years later, the ROI can be calculated as follows:

ROI = 120000 / (20000 + 30000) = 2.4%

Also consider an e-sustainability organization that launches different projects to reduce the carbon footprint of smartphones and their associated devices (earphones, chargers, etc.). E-sustainable organizations often draw attention to the phenomenon of e-waste. There is a concerning number of smartphones and devices sitting unused in people's drawers at home. These devices are either broken, or early adopters upgraded their phones as soon as the latest model is released. People often do not dispose of the old and broken tech properly and dispose of it by throwing it away with the rest of the usual waste. According to The Guardian Labs (2022), e-waste contributes 70% of toxic chemicals in landfills. To combat the destructive effects of unused smartphones tech on the environment, e-sustainable initiatives discourage gadgetry and instead encourage people to sell or fix their old devices. If an e-sustainable organization fixes a collection of broken tech amounting to $25,000, fixed at an additional cost of $15,000, and later sold at a total of $30,000, the ROI can be calculated as follows:

ROI = 30000 / (25000 + 15000) = 0.75%

The ROI of 0.75% is not good. Various reasons can be attributed to this:

1. The project cannot successfully combat the power of consumerism, which includes gadgetry.
2. The project struggles to combat user behaviour in terms of proper disposal of tech. For many tech users, they find it easier to put a broken charger out with the rest of the rubbish instead of finding a proper e-waste facility. Also, the price of advanced tech drops exponentially. In this regard, it is more convenient to store the old/broken device in the drawer and drive to the store to purchase a new device.

3.2. Annualised ROI

The formula of annualised ROI is:

ROI = ((Total profit / Years) * 100) / Total investment

The annualized formula is used to calculate the ROI of projects which make annual returns. I revert to the earlier example of the design of a streaming service to support my explanation of annualised ROI. The e-entrepreneur is looking at two potential projects, each promising to deliver a fully functioning streaming service. Project A involves designing the streaming service platform from end-to-end (i.e., the process of creating a product from its beginning to end), and Project B involves purchasing an off-the-shelf streaming platform and customizing it with the brand identity of the e-entrepreneur. See the initial expense and annual profit of each project outlined in Table 3, which details the financial projections for Project A and Project B.

Table 3: Annual profit

	Project A	Project B
Year 0	-R100 000.00	-R80 000.00
Year 1	R40 000.00	R40 000.00
Year 2	R80 000.00	R80 000.00
Year 3	R120 000.00	R120 000.00
Year 4	R140 000.00	R140 000.00

The ROI for Project A is calculated as follows:

First calculate total profit. Total profit = Total benefits – Total expenses = (40000 + 80000 + 120000 + 140000) – 100000 = 280000

Then calculate ROI. ROI = ((280000 / 4) * 100) / 100000 = 70%

The ROI for Project B is calculated as follows: First calculate total profit. Total profit = Total benefits – Total expenses = (40000 + 80000 + 120000 + 140000) – 80000 = 300000

ROI = ((300000/4) * 100) / 80000 = 93.8%

Project B, with a higher ROI of 93.8%, will likely be chosen by the e-entrepreneur. Several factors may inform this decision. The initial investment of Project A is higher, driven by the incorporation of more features compared to off-the-shelf software in the end-to-end platform. Conversely, Project B requires a much lower initial investment due to its effective but limited features provided by off-the-shelf software. It's worth noting that glitches and bugs are often eliminated in off-the-shelf software before it hits the shelves. However, the end-to-end platform may take a while for programmers to address such issues.

4. Errors in the Activity-on-Node Diagram

The same student who expressed concern about the ROI questions in Assessment 2 also brought errors in the activity-on-node diagram to my attention. They observed that Activity H displays an incorrect early start (ES) of 5, an incorrect early finish (EF) of 11, an incorrect late start (LS) of 5, and an incorrect late finish (LF) of 11. Please refer to Figure 2 below. Consequently, they argue that none of the provided options (a, b, c, or d) for the questions based on the incorrect activity-on-node diagram is valid.

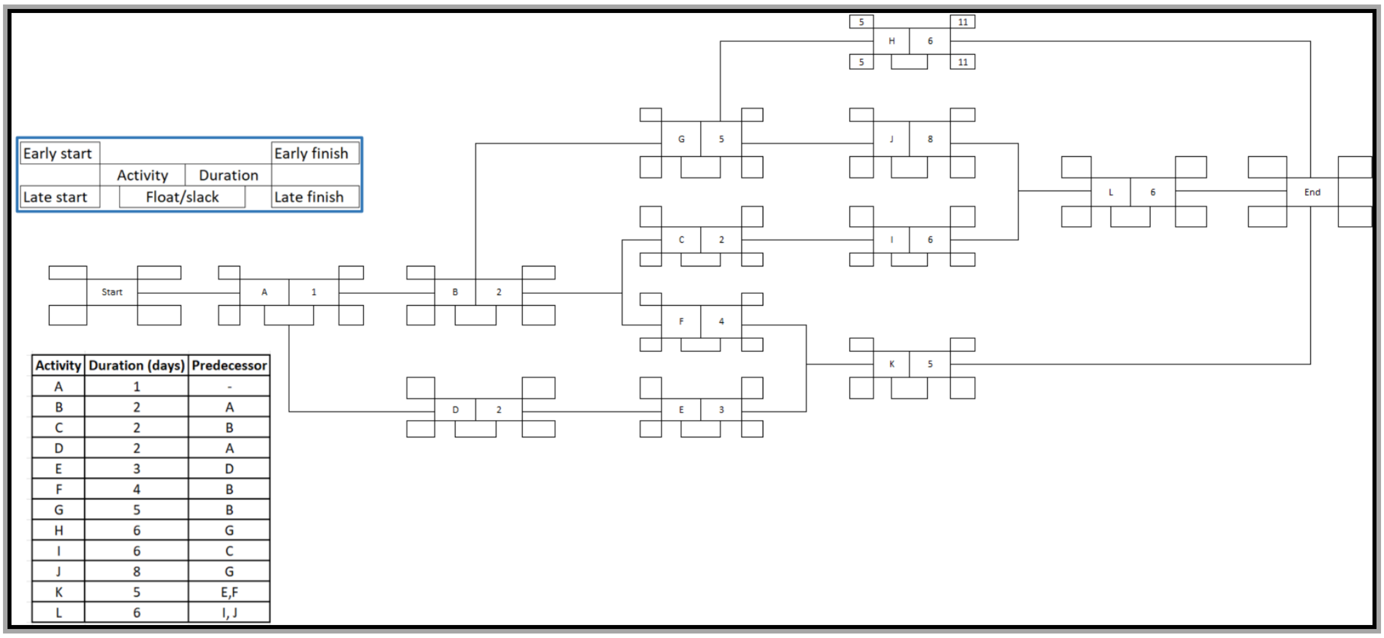

Figure 2: Activity H displaying incorrect ES, EF, LS and LF values.

The student then proceeded to illustrate an annotated diagram (see Figure 3 below) of the correct activity-on-node diagram, populated with the correct ES, EF, LS, and LF.

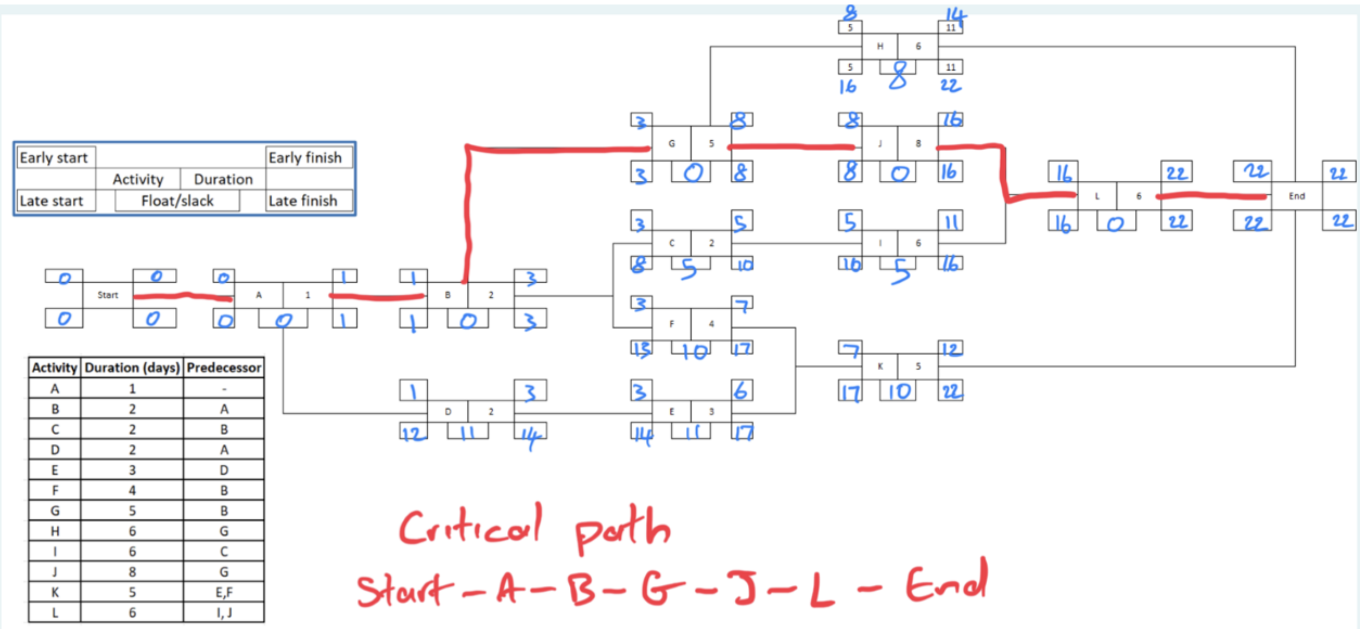

Figure 3. The activity-on-node diagram populated with the correct ES, EF, LS and LF values.

What went wrong?

I created the activity-on-node diagram in Excel, and it was perfect. However, I made the mistake of not clearing the formulas to calculate the ES, EF, LS, and LF of Activity H when I prepped the blank diagram to be part of the question pool for Assessment 2. The result: the ES of Activity H is calculated by adding the ES of Activity G, which is zero (0) after being cleared, to Activity G's duration, which is 5, producing Activity H's (incorrect) ES of 5. This incorrect calculation also resulted in incorrect EF, LS, and LF values for Activity H, as presently presented in the Assessment 2 quiz.

Activities with no successors

Considering the correct activity-on-node diagram illustrated in Figure 3, the student indicates that none of the presented options displays the correct ES, EF, LS, and LF for Activity K. Please refer to Figure 4 below. Instead, the student asserts that Activity K's correct ES is 7, EF is 12, LS is 17, and LF is 22.

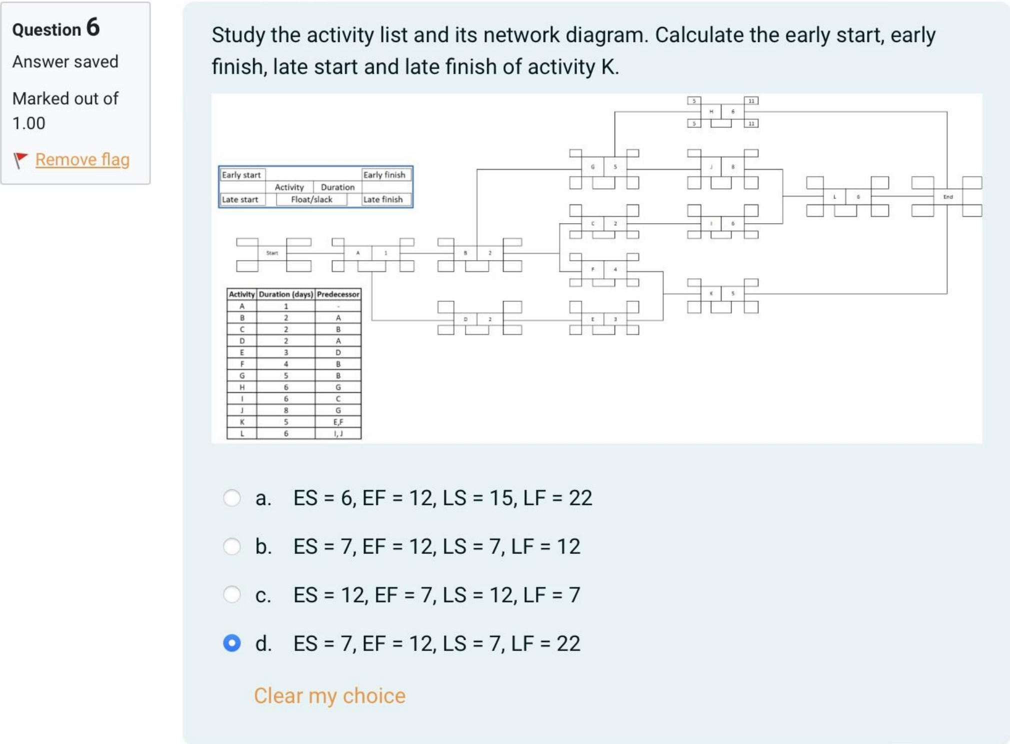

Figure 4: Neither Option a, b, c, or d holds the correct ES, EF, LS and LF for Activity K.

What went wrong?

Considering that Activities H, L, and K do not have successors (i.e., succeeding activities), these activities are succeeded by the END node. In the instance of activities that have no successors, the LF of each activity inherits the highest/latest EF amongst the 'no successor activities'. Therefore, Activities H, L, and K inherit Activity L's EF of 22 because it is the highest EF – the EF of Activity H is 14 and the EF of Activity K is 12, disqualifying their EF from being inherited by the group of 'no successor activities'. Hence, Activity K's LS must be 17, calculated by subtracting Activity K's duration from its LF, i.e., 22 – 5 = 17.

When I initially prepped the Excel sheet with formulas, the ES, EF, LS, and LF of each node contained no values; I started by inserting the formulas to calculate each node's ES, EF, LS, and LF. Regarding Activities H, L, and K, I calculated each of these activity's LF by setting each LF equal to its EF. At this stage, it's acceptable to do so because the nodes contain no values, and one cannot observe which of these three nodes will hold the highest/latest EF. After I finally populated the nodes with values, resulting in Activity L holding the highest/latest EF, I made the mistake of not transferring its EF to also become the LF of Activities H and K.

In contrast to the above, Activities H and K can technically inherit the EF of their own activities. Consider the activity-on-node diagram in the context of representing the launch of a new streaming service platform. Activity L might be the official launch of the streaming service, while

Activity H is the process of documenting the programming code that underpins the system, and Activity K involves documenting the quality assurance (QA) processes that underpin the system. The Project Manager might decide that the writing for Activity H (documenting programming code) must be completed no later than day 14 – the remaining 8 days will be spent on proofreading the documented text. Similarly, the writing for Activity K (documenting QA) must be completed no later than day 12 – the remaining 10 days will be devoted to proofreading the document. In such an instance, a dummy activity (see page 252 in Schwalbe, 2019) – represented by a dotted line – can connect Activities H and K to the END node to represent the remaining 8 and 10 days of proofreading. See Figure 5 below.

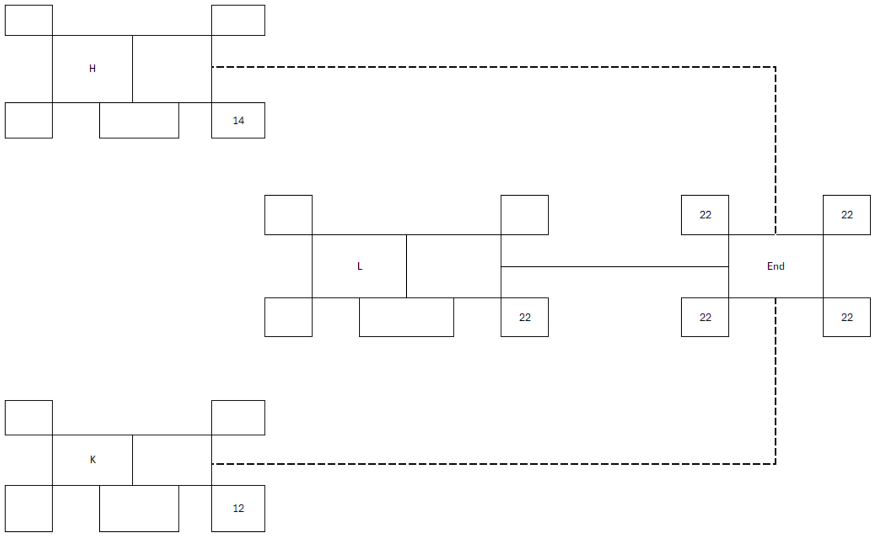

Figure 5: A snapshot of Activities H and K connected to the END node as dummy activities.

Dummy activities are typically noncritical activities that carry zero weight. They are primarily incorporated into an activity-on-node diagram to illustrate logical relationships between activities. In the process of documenting programming code, the focus is on documenting the functionality of the code, with less emphasis on grammar. However, if one of the programmers volunteers to proofread the document, that would contribute to effective quality assurance. The inclusion of dummy activities furthermore suggests that it is not critical for the proofreading activities to finish on day 22 because these activities are not crucial to the successful delivery of the streaming service.

How will the grading of the erroneous activity-on-node questions be handled?

I will configure all the questions that relate to the activity-on-node diagram, to grade ALL the four options as the correct option, this way students will not be marked down for these erroneous questions. To further compensate for the unclear and erroneous questions in Assessment 2, I added a third opportunity to attempt the quiz. Please complete and submit Assessment 2 before its due date of 7 June 2024 8:00 PM.

5. SOURCES CONSULTED

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6. IN CLOSING

I hope this tutorial clears up uncertainty about Assessment 2. If you have any questions, please send me a mail.

Best wishes,

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Enter Jiraiya’s honoured sage style: Bath of boiling oil!