Provide a clear and organized presentation. Show all of your work, give exact values only, and completely simplify your answer.

If $f(x) = \dfrac{\sqrt{3x^3 - 2x^2 - 4x - 1}}{x - \pi^2}$, determine the domain of f in interval notation.

$$
\begin{array}{r|rrrr}
-\dfrac{1}{3} & 3 & -2 & -4 & -1 \\
 & & -1 & 1 & 1 \\
\hline
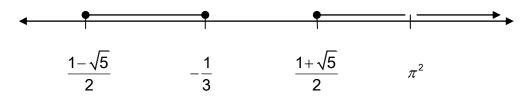 & 3 & -3 & -3 & 0
\end{array}
$$

So, we now have that:

$$f(x) = \dfrac{\sqrt{3x^3 - 2x^2 - 4x - 1}}{x - \pi^2}$$

$$= \dfrac{\sqrt{\left(x + \dfrac{1}{3}\right)\left(3x^2 - 3x - 3\right)}}{x - \pi^2}$$

$$= \dfrac{\sqrt{(3x + 1)\left(x^2 - x - 1\right)}}{x - \pi^2}$$

Now, we have that $(3x + 1)(x^2 - x - 1) \geq 0$ and $x \neq \pi^2$

On a number line, this gives us:

$$\dfrac{1 - \sqrt{5}}{2} \qquad -\dfrac{1}{3} \qquad \dfrac{1 + \sqrt{5}}{2} \qquad \pi^2$$

In interval notation, this gives us:

$$\mathrm{dom} f = \left[\dfrac{1 - \sqrt{5}}{2}, -\dfrac{1}{3}\right] \cup \left[\dfrac{1 + \sqrt{5}}{2}, \pi^2\right) \cup \left(\pi^2, \infty\right)$$